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The resistance of renewal to instructions that devalue the role of contextual cues in a
conditioned suppression task with humans

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Abstract

The renewal of extinguished conditioned behaviour appears to reflect context-dependent learning. The present research used a conditioned suppression task with humans to examine whether instructions concerning the context could influence renewal. Pairings of a conditional stimulus (CS) and unconditional stimulus (US) were made in one context, followed by extinction trials of CS alone in a second context, and test trials of CS alone upon return to the original learning context. Four experiments tested whether the renewal of conditioned suppression observed during test would be attenuated if participants were instructed that the context changes were irrelevant to the predictive relationship between the CS and US. Using a differential conditioning design, no attenuation was found when the instructions were given prior to conditioning (Experiment 1) or immediately prior to the test trials (Experiment 2). The latter result was replicated with a single-cue conditioning design and further controls for exposure to the extinction contexts (Experiment 3). The collection of on-line ratings about the relationship between the contextual changes and the predictive nature of the CS indicated that participants did attend to and believe the instructions (Experiment 4). The results point to the resistance of renewal to explicit instructions that attempt to devalue the role of the contextual cues.

Keywords: Pavlovian conditioning, context, extinction, renewal

Introduction

Although the renewal of conditioned behaviour was reported by Bouton and Bolles in 1979, it has continued to be of interest for researchers in the field of Pavlovian conditioning. In the “ABA” renewal design (Bouton, 2004), conditioned behaviour is acquired in one context (Context A) by pairing a conditional stimulus (CS) with an unconditional stimulus (US). Conditioned behaviour is next extinguished in a second context (Context B) by presenting the CS alone. Finally, test trials of the CS are given in the original acquisition context (Context A). A renewal of conditioned behaviour to the CS during test has been demonstrated in a number of studies using human (Havermans, Keuker, Lataster, & Jansen, 2005; Neumann, 2006; Vansteenwegen et al., 2005; Vervliet, Vansteenwegen, Baeyens, Hermans, & Eelen, 2005) and nonhuman animals (e.g., Bouton & Bolles, 1979; Bouton, García-Gutiérrez, Zilski, & Moody, 2006; see Bouton, 2002, 2004, for reviews). The renewal effect shows that extinction does not lead to a permanent “unlearning” of the original CS-US association, rather, the extinguished conditioned behaviour can return if the right circumstances exist. The practical implications of renewal have been recognised by linking it to relapse following extinction-based treatments, such as exposure therapy (see Bouton, 2002; Bouton & Swartzentruber, 1991 for reviews). This idea has been tested in the context of anxiety disorders (Mineka, Mystkowski, Hladek, & Rodriguez, 1999; Mystkowski, Mineka, Vernon, & Zinbarg, 2003; Mystkowski, Craske, & Echiverri, 2002) and alcohol consumption (Collins & Brandon, 2002).

Contextual cues play a central role in the renewal of extinguished conditioned behaviour. For example, renewal is not limited to the ABA design, but can be observed in procedures that use “ABC” or “AAB” designs that vary the contexts used during acquisition, extinction, and test (Bouton, 2004). The three renewal designs are

common in that test occurs following a removal from the extinction context. Renewal does not merely reflect excitation or inhibition of the acquisition and extinction contexts (Bouton & King, 1983). Rather, the contexts appear to moderate whether the CS-US or CS-noUS association is expressed in behaviour. Further evidence suggests that contextual cues have a greater influence over extinction learning than on acquisition learning (Bouton & King, 1983; Bouton & Peck, 1989). The highly context-specific nature of extinction learning thus appears to be a major contributor to renewal.

Given the importance of contextual cues in renewal, it is theoretically and practically relevant to determine whether experimental manipulations that impact upon them can influence renewal. Gunther, Denniston, and Miller (1998) and Chelonis, Calton, Hart, and Schachtman (1999) showed that renewal in rats can be attenuated if extinction treatment is given in multiple contexts prior to test trials. These findings have been replicated in a conditioned suppression procedure with human participants (Neumann, 2006), but not in subsequent experiments with rats (Bouton et al., 2006). The use of multiple extinction contexts may attenuate renewal by increasing the generalisation of what is learnt during extinction to the test context (Gunther et al., 1998; see Bouton et al., 2006 for a discussion). Collins and Brandon (2002) showed that the renewal of saliva weight and urge to drink in social drinkers could be attenuated if a distinctive cue that was present during extinction was also present during test. The common cue may serve to increase generalisation of learning from the extinction context to the test context. Vansteenwegen, Vervliet, Hermans, Beckers, Baeyens, and Eelen (2006) have recently extending this finding by showing that renewal in a human fear conditioning procedure is larger when the additional cue

presented during test was also present during acquisition in comparison to if the cue was present during extinction.

While prior research has largely used additional cues or context exposures to influence renewal, it is not known whether direct instructions can have any impact. On the one hand, the observation of renewal in animals (see Bouton, 2002) shows that highly evolved cognitive processes are not required to produce renewal. On the other hand, conditioning in humans can involve considerable cognitive evaluation and conscious awareness. For instance, Pavlovian excitatory conditioning has been found only in participants who are aware of the CS-US contingency (Dawson & Schell, 1985). Explicit instruction concerning the US can also mediate the conditioned response. Instructing participants that the US will no longer be presented reduces the size of the conditioned response (Davey & McKenna, 1983). However, this effect may have limits in that it is found for fear irrelevant stimuli as opposed to fear relevant stimuli (Soares & Öhman, 1993; see also Lipp & Edwards, 2002). The cognitive mechanisms that have shown to influence conditioning and extinction processes suggests that human participants base their expectancy of the US on prior experience with the CS and US and other sources, such as language/instruction (Lovibond, 2004).

If renewal is mediated by context dependent knowledge about the predictive relationship between the CS and US, instructions about the role of the context in this relationship might influence renewal. The renewal effect might be attenuated by instructions that attempt to break down the context-dependency of the theoretical CS-noUS association learnt during extinction. This might have important practical implications due to the application of renewal as an explanation for relapse following extinction based treatments. Hence, the present research was conducted to test

whether instructions will influence the renewal of extinguished conditioned behaviour in humans.

Experiment 1

Instructions can conceivably be given at any one of several points during a renewal procedure. The two most relevant are at the start of the experiment, before any context-specific learning occurs, and in between the extinction and test phases, following context-specific learning. Experiment 1 tested whether instructions given at the start of the experiment would attenuate renewal by devaluing the importance of the context on subsequent learning. In other words, the instructions aimed to influence learning in acquisition, and particularly extinction, that is less context-specific. Participants in a Context Devaluation group were instructed that the contextual changes that they might experience during the experiment would be unrelated to the predictive relationship between the CS and US. This group was compared to a No Instruction group. The ABA renewal design was employed in both groups because this design tends to produce the strongest renewal effects (Harris, Jones, Bailey, & Westbrook, 2000) and has resulted in renewal in human research (Havermans et al., 2005; Neumann, 2006). A differential conditioning procedure was used (Öhman, Hamm, & Hugdahl, 2000) in which one CS was paired with the US (CS+) and a second CS was presented alone (CS-) during acquisition. Both the CS+ and CS- were presented alone during extinction. The differential conditioning procedure provides a within-subjects control for the assessment of the acquisition, extinction, and renewal of conditioned suppression through comparisons of the CS+ and CS-.

The present experiments used a conditioned suppression task developed by Arcediano, Ortega, and Matute (1996) and used in prior research on renewal in

humans (Havermans et al., 2005; Neumann, 2006). The task is modelled on the conditioned fear procedure used in animal research that employs an electric shock as the US (e.g., Bouton & Bolles, 1979; Bouton et al., 2006; Gunther et al., 1998). However, in the human analogue, the US is salient not because of its ability to produce unconditional responding, but because of its relevance in the task. The task uses a computer-based format in which participants destroy invading “Martians” by shooting a “laser gun”. However, if participants shoot the laser gun when the Martians have deployed a “laser shield” (the US), it has the consequence of allowing a flood of Martians to invade. Participants can learn to avoid shooting when the laser shield is activated by the presentation of signals (CSs). Participants thus learn to suppress the shooting of the laser gun when the CSs are presented. Conditioned suppression to the CS reflects the anticipated punishment in the context of the task rather than an emotional fear response to the US (Havermans et al., 2005). Despite this procedural difference, the terms conditioned suppression, CS, and US will be used, similar to prior research with this task (Havermans et al., 2005; Neumann, 2006).

Method

Participants

Ten male and 22 female first year psychology students from Griffith University with a mean age of 21.7 years (range 18 to 40 years) participated for course credit. Informed consent was obtained prior to participation in an experimental protocol that was approved by the Human Research Ethics Committee of Griffith University. The participants were randomly allocated to the Context Devaluation group ($n = 16$) or the No Instruction group ($n = 16$) such that there was a similar proportion of males and females in each group.

Apparatus

Each participant completed the task individually in a 3-m square room. The room had light brown sound attenuating material on the walls and a 2.4-m wide x 1.2-m high screen on which the images for the task were displayed. A Dell Optiplex Model GX270 computer was used to present the task via a Panasonic Model PT-L557E LCD projector and to record the participant's responses. The participant sat at a desk positioned 1.7-m from the display screen and responded by pressing the spacebar on the computer keyboard.

The door of the participant's room was left open during the training components of the task, but was closed during the experiment proper. As the participant remained in the same room during the experiment, the physical context was manipulated by changing the background lighting and playing different background sounds. The lights were presented via a panel of Crompton 60-W reflector spot globes mounted 2-m from the ground and directly behind the participant. Two different background colors were produced by illuminating two red or two amber globes to diffusely illuminate the walls of the room. The acoustic component of the context was produced by playing musical digital interface (MIDI) sounds at a tempo of 60 sounds per minute. The MIDI sounds were obtained from the range of percussion instruments and were a base drum sound (MIDI Code 36) and short whistle sound (MIDI Code 71). These sounds were played by a second Dell Optiplex Model GX270 computer fitted with a SoundMAX Integrated Digital Audio sound controller. Sound output was via four Altec Lansing speakers mounted 2-m high in each corner of the room. The final context consisted of a combination of a light and sound. These were an amber light plus the base drum sound and a red light plus the short whistle sound. The nature of which combination served as Context A

and Context B was counterbalanced between participants. Upon debriefing, all participants reported that they had noticed the contextual manipulation.

Martians were represented by a cartoon style face with large teeth, no hair, and elongated eyes. A destroyed Martian consisted of the same graphic but with a red X drawn over it. The CSs consisted of shapes that appeared behind the display of invading Martians. Two shapes were used, an outline of a circle that subtended a visual angle of 10° and an outline of a square that subtended a visual angle of 12° . The Martian laser shield (US) was represented by the screen background rapidly alternating between black and white for 1 s. This had the effect of making it appear as though the screen was flashing.

Procedure

Each participant completed two training phases prior to the experiment proper. In the first training phase, the participants were trained to depress the space bar at a steady rate in order to destroy the invading Martians. All instructions were given in writing on the same screen as the task later appeared. Participants were instructed that the purpose of the task was to destroy Martians that were attempting to invade Earth. They could destroy a Martian by pressing the spacebar just before each Martian appeared on the screen (see Neumann, 2006 for full instructions used for all phases of the task). After the instructions, participants received 100 Martians presented at a rate of one every 300-ms. Each Martian appeared on the screen in sequence. The first Martian appeared in the top left corner of the screen, the second Martian appeared to the right of the first, and so on until 10 Martians completed the row. The next row of Martians began below the first one until eight rows filled the screen. The rows then moved up the screen such that the next row of Martians

appeared at the bottom of the screen. The percentage of Martians destroyed was displayed to the participants at the end of the first training phase.

In the second training phase, the participant was introduced to the laser shield (US). Participants were told that the Martians have now developed a laser shield, represented by the screen flashing intermittently. If the participant tried to shoot the laser gun when the shield was activated it would allow a flood of Martians to invade. Following the instructions, 160 Martians were presented at a rate of one every 300 ms. The laser shield was presented at random times and as the presentations were unwarned, the participants were responding when the shield was up. This had the consequence of allowing 100 Martians to fill six lines of the screen. During this time, the screen continued to flash between black and white. The second training phase finished with the percentage of Martians destroyed being shown.

The experiment proper began next in which the signals (CSs) were introduced. The participants were told that they may be able to learn when the Martians are about to activate the laser shield by the presentations of signals. The participants were also told that while some signals would help to predict the activation of the laser shield, that there might also be some false signals, and that a signal's meaning may change during the course of the experiment. Participants were encouraged to destroy as many Martians as possible while avoiding the laser shield. Additional instructions were then given to the participants depending on their randomly assigned group.

Participants in the Context Devaluation group were given the following instructions:

You may also notice that the colours of the lights and the background sound in the room may also change. It is very important to note that the changes in a signal's meaning and the changes in the lights and sounds of the room are NOT RELATED. They are NOT RELATED even though, at times, it may

appear as though they are. REMEMBER: Just one shot when the shield is up (FLASHING SCREEN) and the Martian invaders will come swarming in.

Participants in the No Instruction group were not given any explicit instruction about the context changes. The instructions merely finished with “REMEMBER: Just one shot when the shield is up (FLASHING SCREEN) and the Martian invaders will come swarming in.”

Following the instructions the experimenter initiated the first context (Context A) and the task began. The Martians were presented at a rate of one every 200 ms. Presentations of the CSs and US occurred at predetermined times and sequences. The CS and US presentations were arranged into three phases: acquisition, extinction, and test. All phases ran continuously without any further instructions. In the first phase, acquisition, there were 17 presentations of one CS followed by the laser shield “US” (CS+) and 17 presentations of the other CS alone (CS-). The nature of which signal served as the CS+ and CS- was counterbalanced between participants. Onset of the US coincided with the offset of the CS+. Duration of the CS presentations were 3-s on Trials 1, 5, 9, 13, and 17 and 1-s on the remaining trials to help reduce the predictability of the US onset. At the end of the acquisition phase, the context was changed to Context B. The extinction trials then began. During extinction, there were 21 presentations of the CS+ alone and 21 presentations of the CS- alone. The CS+ was no longer followed by the US. The CSs were presented for 3-s on Trials 1, 5, 9, 13, 17, and 21 and for 1-s on the other trials. After the extinction trials, the context was changed back to Context A and the test trials were presented. The test phase consists of 3 presentations each of the CS+ and CS-. No US presentations were made. The CS duration was 3-s on all test trials.

The sequence of trials in each phase were developed using the following principles: (a) the order of the CS+ and CS- presentations were randomised with the restriction that no more than three presentations of the same type of CS could be made in succession, (b) the first two presentations at the start of each phase were a CS+ and a CS-, (c) the nature of which CS was presented first in each phase was counterbalanced across participants, and (d) the intertrial intervals varied at random between 5 to 10-s with a mean of 7.5-s CS offset to CS onset. Counterbalancing resulted in 16 unique trial sequences that were distributed evenly across the participants. The dependent variable was the suppression ratio calculated through the formula $x/(x + y)$. In this formula, x represents the number of responses during the 3-s of the CS presentation and y represents the number of responses in the 3-s immediately before the CS presentation. A ratio of 0 occurs when there is absolute suppression during the CS, while a ratio of .5 occurs when there is no suppression. Only trials in which the CS duration was 3-s were used for the calculation of suppression ratio and entered into the statistical analyses (Arcediano et al., 1996). The acquisition trials are thus labelled A1, A5, A9, A13, and A17, the extinction trials are labelled E1, E5, E9, E13, E17, and E21, and the test trials are labelled T1, T2, and T3.

Results and Discussion

The mean conditioned suppression ratio in each group across the acquisition, extinction, and test phases is shown in Figure 1. As can be seen, the results were very similar for the two groups. Conditioned suppression developed during the CS+ during acquisition, was lost in extinction, and was renewed during test. The mean suppression ratio was examined with ANOVAs that used Greenhouse-Geisser adjusted degrees of freedom for all main effects and interactions involving more than

two within-subjects levels to correct for violations in the sphericity assumption. The F ratios are reported with the unadjusted degrees of freedom and the ϵ used in the correction. An α -level of .05 was used to assess statistical significance.

To examine whether conditioned suppression developed during the CS+, a 2 x 2 x 5 (Group x CS x Trial) ANOVA was conducted for the acquisition phase. The main effect for CS, $F(1, 30) = 246.84, p < .0005$, main effect for Trial, $F(4, 120) = 8.52, \epsilon = .57, p < .0005$, and CS x Trial interaction, $F(4, 120) = 55.43, \epsilon = .76, p < .0005$, were all highly significant. As can be seen in Figure 1, there was clear suppression of responding during the CS+ and no suppression of responding during the CS- by the last acquisition trial. Figure 1 also suggests that conditioned suppression during the CS+ tended to diverge between the groups on later acquisition trials. However, this differentiation was not statistically significant as shown by all main effects and interactions involving the group factor failing to reach significance, all $F_s < 2.67$.

Insert Figure 1 about here

The extinction of conditioned suppression was examined with a 2 x 2 x 6 (Group x CS x Trial) ANOVA for the extinction trials. A main effect for CS, $F(1, 30) = 44.09, p < .0005$, a main effect for Trial, $F(5, 150) = 100.48, \epsilon = .34, p < .0005$, and a CS x Trial interaction, $F(5, 150) = 38.46, \epsilon = .31, p < .0005$, all confirmed that extinction of conditioned suppression was completed by the last extinction trial. Figure 1 also suggests that there was a slight increase in conditioned suppression for the CS- on the first extinction trial relative to the last acquisition trial. To examine this effect, a Group x CS x Trial ANOVA was conducted by comparing between the

two trials. This analysis resulted in a main effect for CS, $F(1, 30) = 164.48, p < .0005$, and a CS x Trial interaction, $F(1, 30) = 4.85, p = .035$. Post hoc analysis to examine main effects and interactions reported in this and subsequent experiments were conducted with t tests that were adjusted for the accumulation of Type I error by using Sidak's multiplicative inequality (Games, 1977). The difference between the trials for the CS+ was not significant, $t = 1.07, p > .05$, whereas the difference between the trials for the CS- approached significance using corrected α -values, $t = 2.01, p = .11$. The reduction in suppression to the CS- following a change of context between the acquisition and extinction phases thus appears to be a small effect.

Two strategies were used to test the extent to which renewal of conditioned suppression was observed. The first strategy examined the differences between the CS+ and CS- during the test trials. Renewal would be evidenced by greater suppression during the CS+ (the CS paired with the US in acquisition) than during the CS- (the control CS). However, renewal may also be defined as an increase in suppression on the first test trial relative to the last extinction trial. This increase in suppression should be observed for the CS+ and not for the CS-, as only the former was associated with the US during acquisition. The second strategy therefore compared the last extinction trial and first test trial for both the CS+ and CS-.

A 2 x 2 x 3 (Group x CS x Trial) ANOVA was used to examine conditioned suppression during the test trials. The analyses yielded a main effect for CS, $F(1, 30) = 8.17, p = .008$, a main effect for Trial, $F(1, 60) = 9.13, \epsilon = .61, p = .003$, and a CS x Trial interaction, $F(1, 60) = 9.67, \epsilon = .62, p = .002$. Post hoc analyses were used to examine the interaction by comparing between CSs on each test trial. The analyses confirmed that conditioned suppression was greater during the CS+ than during the CS- on the first test trial, $t = 4.23, p < .01$, whereas there was no difference on

subsequent trials, all t s $< .25$. The lack of any differences between the CS+ and CS- on the latter test trials reflects that the CS+ was not followed by the US during test. Contrary to expectations, there was no effect of the instructions on conditioned suppression during the test trials as shown by all main effects and interactions involving the group factor failing to reach significance, all F s < 1.55 .

The second test for renewal employed a 2 x 2 x 2 (Group x CS x Trial) ANOVA to compare conditioned suppression between the last extinction trial and first test trial. The outcome of these analyses supported the analyses during the test phase. All main effects and interactions involving the group factor were not significant, all F s $< .60$, showing that conditioned suppression during the CSs were the same in the groups at the end of extinction and the start of test. However, renewal of conditioned suppression was confirmed by a main effect for CS, $F(1, 30) = 16.13$, $p < .0005$, a main effect for Trial, $F(1, 30) = 11.79$, $p = .002$, and a CS x Trial interaction, $F(1, 30) = 9.59$, $p = .004$. Follow up analyses showed that conditioned suppression was greater on the first test trial than on the last extinction trial for the CS+, $t = 4.81$, $p < .01$, but not for the CS-, $t = .62$, $p > .05$.

The present results showed that instructing participants prior to conditioning that the contextual changes would be unrelated to the predictive relationship between the CS and US did not attenuate the renewal effect. It was hypothesised that the instructions might attenuate renewal given the context dependency of extinction learning and the important role of cognitive processes in human Pavlovian conditioning. Evidence of a renewal effect was observed in the Context Devaluation group when performance during the CS+ on the first test trial was compared with the CS- and when the first test trial was compared with the last extinction trial. At no stage during the acquisition, extinction, and test phases was there any evidence that

the instructions influenced behaviour. One interpretation of this effect is that renewal in humans is mediated by processes that cannot be modified by instructions.

However, such a conclusion must be considered tentative at this stage and in need of further experimental support.

Experiment 2

It may be premature to use the results of the previous experiment as evidence that the renewal effect cannot be influenced by instructions about the context. The failure to observe attenuation may reflect that the instructions were given at the start of the experiment. Participants may have disregarded or even forgotten the instructions throughout the course of the experiment such that they had little impact on behaviour at the crucial time when the context was switched between extinction and test. The next experiment therefore employed instructions that were given in between the extinction and test phases. Placement of the instructions at this stage should serve to increase their saliency at the time in which the test for renewal is conducted. These instructions required participants to revalue the role of the context in the predictive relationship between the CS and US. A Context Revaluation group was told that the context changes they had experienced throughout the experiment were unrelated to whether the CS predicts the US or not. A second No Instruction group was used as a control for the fact that the experiment was interrupted between the extinction and test phases. If the instructions have an impact on the renewal effect, a return of conditioned suppression should be observed in the No Instruction group but not in the Context Revaluation group.

Method

Participants

The participants were 10 male and 22 female first year psychology students from Griffith University who did not participate in Experiment 1. The mean age of the participants was 23.6 years (range 17 to 44 years). The participants were randomly assigned to either the Context Revaluation group ($n = 16$) or No Instruction group ($n = 16$) such that there was a similar number of males and females in each group.

Apparatus and Procedure

The methods of the present experiment followed that used in Experiment 1 with the exception of the instructions given to the participants. In the present experiment there were no additional instructions given to the participants immediately prior to the experiment informing them that the contextual changes are unrelated to the relationships between the signals and activation of the laser shield. There were, however, additional instructions given in between the extinction and test phases. At the end of the extinction phase, and after the context was changed from Context B to Context A, the task was paused. The experimenter entered the participant's room and read out instructions that depended on the participant's randomly assigned group. Participants in the Context Revaluation group were given the following instruction:

You may have noticed that the color of the lighting in the room and the sounds inside the room have changed during the experiment. However, these changes are actually unrelated to the task you are performing such as whether a signal predicts when the Martian shield (flashing screen) will occur or not. They are unrelated even though they may have appeared to be. I will now close the door and continue the last part of the experiment.

Participants in the Irrelevant Instruction group were given instructions that controlled for the interruption of the experiment. The experimenter entered the room and stated the following:

I would like to check the connection for the keyboard [checks connection].

Okay, it looks fine. I will now close the door and continue the last part of the experiment.

After the instructions, the experimental trials continued and consisted of the presentation of the test trials as described for Experiment 1.

Results and Discussion

Figure 2 shows the mean suppression ratio across each experimental phase for the two groups. Conditioned suppression to the CS+ was acquired during acquisition and it was lost during extinction. In addition, a renewal of conditioned suppression to the CS+ was observed on the first test trial regardless of the instructions given. A 2 x 2 x 5 (Group x CS x Trial) ANOVA conducted for the acquisition phase confirmed that conditioned suppression was acquired by yielding a main effect for CS, $F(1, 30) = 255.45, p < .0005$, a main effect for Trial, $F(4, 120) = 3.69, \epsilon = .51, p = .029$, and a CS x Trial interaction, $F(4, 120) = 61.44, \epsilon = .74, p < .0005$. The slight differentiation between the groups at the end of acquisition for suppression to the CS+ seen in Figure 2 was not statistically reliable as shown by all main effects and interactions involving the group factor failing to reach significance, all $F_s < 2.17$.

Insert Figure 2 about here

A 2 x 2 x 6 (Group x CS x Trial) ANOVA conducted for the extinction phase showed a main effect for CS, $F(1, 30) = 27.32, p < .0005$, a main effect for Trial, F

(5, 150) = 68.37, $\epsilon = .28$, $p < .0005$, and a CS x Trial interaction, $F(5, 150) = 20.13$, $\epsilon = .27$, $p < .0005$. As can be seen in Figure 2, there was no difference in the suppression ratio between the CS+ and CS- on the last extinction trial. As in Experiment 1, analyses were conducted to compare conditioned suppression between the last acquisition trial and the first extinction trial. The 2 x 2 x 2 (Group x CS x Trial) ANOVA resulted in a main effect for CS, $F(1, 30) = 91.91$, $p < .0005$, and a CS x Trial interaction, $F(1, 30) = 12.34$, $p = .001$. All other main effects and interactions were not significant, all $F_s < 3.70$. Post hoc analyses revealed that conditioned suppression increased from acquisition to extinction for the CS-, $t = 3.01$, $p < .05$, but not for the CS+, $t = 1.96$, $p > .05$. This difference supports the similar, although non-significant, effect observed in Experiment 1 and suggests that there was some increase in suppression to a CS that predicted the absence of the US following a context change.

The first test for renewal used a 2 x 2 x 3 (Group x CS x Trial) ANOVA to examine conditioned suppression during the test trials. These analyses showed a main effect for CS, $F(1, 30) = 13.29$, $p = .001$, a main effect for Trial, $F(2, 60) = 10.17$, $\epsilon = .68$, $p = .001$, and a CS x Trial interaction, $F(2, 60) = 6.12$, $\epsilon = .72$, $p = .01$. Post hoc analyses confirmed the presence of renewal with greater suppression during the CS+ than during the CS- on the first test trial, $t = 4.39$, $p < .01$, although the differences on subsequent trials were not significant, all $t_s < 1.75$. Contrary to expectations, but similar to the outcomes of Experiment 1, there were no differences between groups during the test phase, all $F_s < 1.58$. This supports the conclusion that the renewal effect was identical in the two groups.

The second test for renewal employed a 2 x 2 x 2 (Group x CS x Trial) ANOVA to compare between the last extinction trial and first test trial. The ANOVA

yielded a main effect for CS, $F(1, 30) = 12.48, p = .001$, a main effect for Trial, $F(1, 30) = 8.77, p = .006$, and a CS x Trial interaction, $F(1, 30) = 7.91, p = .009$. Post hoc analyses confirmed that conditioned suppression for the CS+ was greater on the first test trial than on the last extinction trial, $t = 4.33, p < .01$, whereas there was no difference between trials for the CS-, $t = .31, p > .05$. There were no differences between the groups in conditioned suppression on the last extinction trial or first test trial, as confirmed by the statistical analyses failing to find any main effects or interactions involving the group factor, all $F_s < .42$.

The present results showed that instructing participants immediately prior to the test phase that the contextual changes are unrelated to the predictability of the CS-US or CS-noUS relationship did not attenuate the renewal effect. These findings support those obtained in Experiment 1 and suggest that the lack of attenuation observed in that experiment may not merely reflect the placement of the instructions at the start of the experiment. It is untenable to suggest that the participants in the present experiment had forgotten the instructions when those instructions were given immediately prior to the test trials. The present results point towards the resistance of the renewal effect to instructions that attempt to devalue the role of the context on the predictive relationship between the CS and US.

Experiment 3

A third experiment was conducted to confirm that the lack of an effect of instructions in the previous experiments was not an artifact of the methodology used. The previous experiments used a differential conditioning procedure in which a CS+ was paired with the US and a CS- was presented alone during acquisition. The CS- serves as a within-subjects control for conditioning. While the differential conditioning procedure is commonly used in human Pavlovian conditioning research,

it is not often used in animal research. In addition, it was associated with an unexpected finding in the present experiments. An increase in suppression to the CS- on the first extinction trial relative to the last acquisition trial was found. The increase in suppression to the CS- is unexpected because the CS- was not associated with the US during acquisition. It may reflect that there was a loss of generalisation of the meaning of the CS- (i.e., that it predicted US absence) following the change of context from acquisition to extinction. The present experiment thus tested whether the outcomes of Experiment 2 would be replicated with a simpler, single-cue conditioning design and a between-subjects control for conditioning.

The present experiment also incorporated additional controls over the exposure to the acquisition context prior to the test phase. A simple explanation of renewal is that it reflects a direct excitatory association between the context and US. Renewal occurs in the ABA design merely due a return to the original excitatory context. The differential conditioning procedure provides some control over this alternative explanation with the CS-. However, such a control is not present when a single-cue conditioning design is used. The present experiment therefore compared an ABA renewal design with an AAA and No Extinction (NE) design and additional controls for context exposure. Participants in the ABA design received acquisition trials in context A, additional exposure to context A, extinction trials in context B, prior to test trials in context A. The AAA design had participants receive acquisition, extinction, and test trials in the same context. These participants also received exposure to context B as a control for the exposure to this context in the ABA design. Participants in the NE design received the same sequence of contexts as the ABA design except that no CS was presented during extinction. Finally, the present experiment crossed the three conditioning designs with the instructional manipulation

as used in Experiment 2. Renewal was tested by using both a within subjects comparison between the last extinction trial and first test trial and a between-groups comparison during the test phase.

Method

Participants

Thirteen male and 67 female first year psychology students from Griffith University with a mean age of 23.0 years (range 17 to 53 years) participated for course credit. None had participated in the previous experiments. All participants were randomly assigned to one of six groups by crossing the three designs of AAA, ABA, and NE with the two instruction groups of Context Revaluation (R) and No Instruction (N). Eight participants were subsequently excluded from the analyses because of failing to show adequate extinction of conditioned suppression, defined as having suppression ratios less than .20 on the last extinction trial. The final sample sizes in each group were as follows: N-AAA ($n = 12$), N-ABA ($n = 12$), N-NE ($n = 11$), R-AAA ($n = 12$), R-ABA ($n = 12$), R-NE ($n = 13$) and the proportion of males and females in each group were similar.

Apparatus and Procedure

The methods of Experiment 3 were based on those used in Experiment 2, except that the present experiment employed a single-cue conditioning design, additional groups, and further controls over the exposure to the context. Only one CS was used and it consisted of a superimposed circle and cross that subtended a visual angle of 12° . Table 1 shows the design of the conditioning trials and exposure to the context in each group of the experiment. There were six groups formed by crossing the two types of instructions and three types of conditioning designs. In the acquisition phase, all participants received 17 presentations of the CS paired with the

US in Context A. The CS duration was 3-s on Trials 1, 5, 9, 13, and 17 and 1-s on all other trials. After acquisition, the context was changed to Context B for participants in the AAA conditioning design. Participants in the ABA and NE designs remained in Context A, where they continued to perform the task while exposed to the context, but no CS or US presentations were made. Context exposure was for the same duration as the subsequent extinction phase. After the context exposure, the context was changed from Context B to Context A for participants in the AAA design. The context was changed from Context A to Context B for participants in the ABA and NE designs. The extinction phase then began for participants in the AAA and ABA designs. These participants received 21 presentations of the CS and no US was presented. The duration of the CS was 3-s on Trials 1, 5, 9, 13, 17, and 21 and 1-s on all other trials. Participants in the NE design did not receive any presentations of the CS or US, but continued to perform the task while being exposed to the context for the same duration as the other groups. Following the extinction phase, the context was changed from Context B to Context A in the ABA and NE design groups and it was left on Context A for the AAA design groups. The experimenter then entered the room and gave participants the instructions as detailed in Experiment 2. Following the instructions, the test trials were given and consisted of three presentations of the CS for 3-s duration on all trials.

Results and Discussion

The mean suppression ratio across the acquisition, extinction, and test phases of the experiment for all groups is shown in Figure 3. As all groups received acquisition trials, a 2 x 3 x 5 (Instruction x Design x Trial) ANOVA was used to examine conditioned suppression in this phase. The analyses yielded a highly significant main effect for Trial, $F(4, 264) = 79.09$, $\varepsilon = .59$, $p < .0005$, and no other

effects were significant, all $F_s < 1.74$. As can be seen in Figure 3, all groups showed the development of conditioned suppression across the acquisition trials.

The groups that received the AAA and ABA designs received extinction trials, whereas the groups that received the NE design did not. Conditioned suppression during the extinction phase was therefore examined with a $2 \times 2 \times 6$ (Instruction x Design x Trial) ANOVA for only the AAA and ABA design groups. A significant main effect for Trial was found, $F(5, 220) = 96.39$, $\epsilon = .51$, $p < .0005$, reflecting that conditioned suppression was lost during extinction in all groups. The Instruction x Design interaction approached significance, $F(1, 44) = 3.78$, $p = .06$, and all other effects were not significant, all $F_s < 2.22$. Conditioned suppression on the last acquisition trial and first extinction trial was examined with a $2 \times 2 \times 2$ (Instruction x Design x Trial) ANOVA. The analysis resulted in a main effect for Trial, $F(1, 44) = 4.31$, $p = .04$, suggesting that there was a slight reduction in suppression from acquisition to extinction. However, this decrease did not interact with the nature of the context change with all main effects and interactions involving the between-groups factors failing to reach significance, all $F_s < 2.79$.

 Insert Figure 3 about here

Similar to the previous experiments, two strategies were employed to test for renewal on the test trials. The first employed a $2 \times 3 \times 3$ (Instruction x Design x Trial) ANOVA for the three test trials. This analysis showed a main effect for Trial, $F(2, 132) = 22.01$, $\epsilon = .90$, $p < .0005$, a main effect for Design, $F(2, 66) = 14.39$, $p < .0005$, and a Design x Trial interaction, $F(4, 132) = 7.95$, $\epsilon = .90$, $p < .0005$. There was greater conditioned suppression in groups with the NE design than in groups with

the AAA design on the first, $t = 9.79, p < .01$, and second, $t = 5.50, p < .01$, test trials. The same difference emerged between the NE and ABA design groups on the first, $t = 5.99, p < .01$, and second, $t = 5.18, p < .01$, test trials. The crucial test is between the groups with the AAA and ABA designs. This comparison confirmed that renewal was observed with greater suppression on the first test trial in groups with the ABA design than in groups with the AAA design, $t = 3.80, p < .01$. No other comparisons were significant, all $ts < 2.68$. During the test phase, the instructions had no effect on conditioned suppression as shown by all main effects and interactions involving the instruction factor failing to reach significance, all $Fs < 1.27$. This supports the outcomes of Experiment 2 in which no effects of instructions were found in a differential conditioning procedure.

The second test for renewal used a 2 x 2 x 2 (Instruction x Design x Trial) ANOVA to compare between the last extinction trial and first test trial for the groups with the AAA and ABA conditioning designs. The analyses yielded a main effect for Trial, $F(1, 44) = 15.59, p < .0005$, a main effect for Design, $F(1, 44) = 7.12, p = .011$, and a Design x Trial interaction, $F(1, 44) = 6.74, p = .013$. Post hoc analyses showed that conditioned suppression increased from the last extinction trial to the first test trial in the ABA design groups, $t = 4.61, p < .01$, but not in the AAA design groups, $t = .94, p > .05$. From Figure 3, it also appears that there was an increase in suppression from the last extinction trial to the first test trial in the R-AAA group. However, all main effects and interactions involving the Instruction factor were not significant, all $Fs < 1.10$. Moreover, a follow up analysis using a post hoc t test conducted only on the R-AAA group did not yield any significant differences between trials, $t = 1.33, p > .05$, suggesting that the apparent decline is more likely to reflect random variation than the effect of the instructions.

The results of the present experiment support the conclusions from Experiment 2. Informing participants immediately prior to test that the context changes are irrelevant to the predictive relationship between the CS and US had no effect in attenuating the renewal of conditioned suppression. Although the size of the renewal effect was not of the same magnitude as that found when no extinction was given (compare ABA design groups with NE design groups in Figure 3), this difference is consistent with other research (e.g., Havermans et al., 2005). The present experiment employed a simpler conditioning design in which only one CS was used. It would appear that the differential conditioning design cannot account for the failure of the instructions to attenuate renewal in Experiment 2. The present experiment also included additional exposure to the acquisition context and corresponding control groups to ensure that the observed renewal effect does not merely reflect an excitatory association between the context and US. The replication of the outcomes of Experiment 2 with a different conditioning procedure and additional exposure to the acquisition context is encouraging. It suggests that whatever the reason for the failure of the instructions to attenuate renewal, it appears to be robust across a range of conditioning designs.

Experiment 4

The findings from the previous experiments suggest that the renewal effect in humans is due to processes which are resistant to modification by instructions. One possible interpretation is that during the test trials, in which the participant is returned to the acquisition context, non-cognitive processes may promote renewal. However, the suggestion that the renewal effect reflects a non-cognitive process in humans does not seem consistent with evidence showing that cognitive processes are important in extinction (Lovibond, 2004). A perhaps less theoretically interesting interpretation of

the present results, and one that is consistent with a cognitive view of human conditioning, is that the lack of an effect of instructions reflects that the participants did not believe the instructions provided by the experimenter. In Experiment 1, when the instructions were given at the start of the experiment, the participants may have realised the discrepancy between the instructions and their own experiences in observing an apparent relationship between the context and the predictive nature of the CS+. Participants may choose to prefer their own experiences over and above the instructions. Similarly, when the instructions required participants to revalue the role of the context immediately before the test phase (Experiments 2 and 3), the participants may have preferred to disregard the instructions that were not consistent with their own experiences.

The possibility that the participants did not believe or trust the instructions could be tested by applying the methods described by Davey (1987) in which participants rate their confidence or believability in the instructions that they are given. Alternatively, participants could be required to perform a second task concurrent with the learning task in which their evaluation of the relationship between the context and the predictive nature of the CS is assessed. The latter method was adopted in the present experiment by asking participants to rate the extent to which the meaning of the signal (CS) is related to the lights and sounds (context) in the room. The ratings were provided on a continuous scale to enable participants to indicate varying degrees of confidence in their answer. The ratings of most interest will be those that are provided immediately before the instructions are given and those that are provided after. If the lack of an attenuation of the renewal effect reflects that participants disregard the instructions, there should be no difference in the ratings provided in the no instruction and revaluation groups. However, if participants do

attend to the instructions a difference should emerge between the two instruction groups. In particular, participants in the revaluation group should show a reduction in their assessment on the extent to which the predictive meaning of the CS and the context are related after the instructions are given. In contrast, participants who are given no instruction should show no change in their assessment.

The fourth experiment thus provided a test of the hypothesis that the instructions would influence the participant's ratings of the relationship between the context and the meaning of the CS. The conditioning design followed that used in Experiment 3 and compared an ABA renewal design with an AAA design in which only one CS was presented and additional controls for context exposure were used. The two conditioning designs were crossed with the instructional manipulation as used in Experiment 2 and 3 in which instructions were provided between the extinction and test stages. Although the change in the ratings immediately before and after the instructions are of most interest, participants were also asked to provide ratings throughout the experiment in order to integrate the secondary rating task across the entire learning task.

Method

Participants

Thirteen male and 35 female first year psychology students from Griffith University with a mean age of 26.0 years (range 17 to 48 years) participated for course credit. None had participated in the previous experiments. The participants were assigned to one of four groups formed by crossing the two renewal designs (AAA and ABA) with the two instruction methods of Context Revaluation and No Instruction (i.e., N-AAA, N-ABA, R-AAA, R-ABA). Participants were randomly

assigned with the restriction that there were 12 participants in each group and that the number of males and females in each group were similar.

Apparatus and Procedure

The methods replicated that used in Experiment 3 with the following two exceptions. First, there were no groups in which the extinction phase was omitted (i.e., the No Extinction groups were not used) to result in the four groups of N-AAA, N-ABA, R-AAA, and R-ABA. Second, subjective ratings were obtained from participants at predetermined times during the experiment. Following the two training sessions, the experimenter placed a custom-built dial and pointer on the table in front of the participant. The dial could be rotated about 270° such that the extreme left was labelled “Yes”, the central position was labelled “Uncertain”, and the extreme right was labelled “No”. The participant was instructed that during the experiment, the task would be interrupted at various times for them to answer questions about their experiences. The participant was asked to use the dial and pointer to indicate their answer and it was stressed that the dial could be moved at any place in between the extremes to indicate the degree of confidence in their answer. Following these instructions, the trials for the main task began.

To present the question to the participants, the screen display was paused without warning during the task and a message box appeared on the screen. The message box contained the following statement and question: “Please make a rating using the dial and pointer. Is the meaning of the signal (i.e., whether it is followed by the Martian shield or not) related to what lights and sounds are present in the room?”. After the participant provided a rating, the experiment continued. The ratings were acquired via a PowerLab 4/20 data acquisition system (ADInstruments) in which the dial and pointer produced a voltage change that was displayed via the system software

on a computer monitor located in a room adjacent to the participant room. The voltage changes were rescaled such that they varied from –100 (Yes), to 0 (Uncertain), up to 100 (No). As the scale was continuous, ratings in between any of these levels could also be made. The data was sampled at 400 Hz and stored off-line for later quantification.

The message box and question presented to the participant was the same throughout the entire experiment. Although the critical times for presentation of the question were immediately before and after the instruction manipulation, it was also presented at earlier times in order for the participant to be familiar with the procedure of providing ratings. In addition, as the context was changed during the experiment, the question was also presented during different contexts. For the ABA renewal groups, the question was presented at the following times: start of acquisition in Context A, end of acquisition in Context A, start of context exposure in Context A, end of context exposure in Context A, start of extinction in Context B, end of extinction in Context B, start of the test trials (but after the instruction) in Context A, and end of the test trials in Context A. The same times of presentation were used for the AAA design groups, with all ratings made in context A except at the start and end of context exposure (Context B). When two ratings occurred in close succession (e.g., end of acquisition and start of context exposure), they occurred after a minimum of 30 s had elapsed after the participant had provided their first rating. During this period a context change or instruction may have been given depending on the group and phase of the experiment.

Results and Discussion

Figure 4 shows the mean suppression ratio across the acquisition, extinction, and test phases of the experiment for all groups. As can be seen, the results were very

similar to that obtained in Experiment 3 in that all groups showed acquisition and extinction of conditioned suppression with a renewal of suppression occurring in the ABA design groups regardless of the instruction given. A $2 \times 2 \times 5$ (Instruction x Design x Trial) ANOVA for the acquisition trials yielded a highly significant main effect for Trial, $F(4, 176) = 70.83$, $\epsilon = .73$, $p < .0005$, and no other effects were significant, all $F_s < 1.32$. A $2 \times 2 \times 6$ (Instruction x Design x Trial) ANOVA for the extinction trials also yielded a significant main effect for Trial, $F(5, 220) = 65.06$, $\epsilon = .52$, $p < .0005$. As can be seen, all groups showed very little suppression of responses in the presence of the CS by the last extinction trial. All other main effects and interactions were not significant, all $F_s < 2.09$.

The test of renewal that employed a $2 \times 2 \times 3$ (Instruction x Design x Trial) ANOVA for the three test trials yielded a main effect for Trial, $F(2, 88) = 7.97$, $\epsilon = .58$, $p = .005$, a main effect for Design, $F(1, 44) = 4.32$, $p = .04$, and a Design x Trial interaction, $F(2, 88) = 8.86$, $\epsilon = .58$, $p = .003$. As can be seen in Figure 4, there was more conditioned suppression in the ABA design groups than in the AAA design groups on the first test trial, $t = 3.67$, $p < .01$, but not on the subsequent test trials, both $t_s < 1$. There was no effect of the instruction manipulation, as shown by all other main effects and interactions failing to reach significance, all $F_s < 1$. The second test for renewal that used a $2 \times 2 \times 2$ (Instruction x Design x Trial) ANOVA to compare between the last extinction trial and first test trial yielded a Design x Trial interaction, $F(1, 44) = 10.12$, $p = .003$. Post hoc analyses confirmed that conditioned suppression increased from the last extinction trial to the first test trial in the ABA design groups, $t = 3.18$, $p < .01$, whereas there was no significant change for the AAA design groups, $t = 1.15$, $p > .05$.

 Insert Figure 4 about here

The pattern of results observed with conditioned suppression during the learning task replicates the prior experiments in that instructing participants to revalue the role of the context did not attenuate the ABA renewal effect. The ratings obtained during the experiment in response to the question of whether the participant thought that the context is related to the changes in the predictive meaning of the CS will help to determine whether this lack of an effect is due to the parsimonious explanation that participants did not believe the instruction. The important comparison is the change in the participant's perception of the meaning of the context immediately prior to the instruction (at the end of extinction) and immediately after the instruction (during the test trials). Figure 5 shows the rating provided at the start of the test trials and at the end of the test trials as a change from the rating provided at the end of extinction. Positive scores indicate that participants gave higher ratings of "Yes" and negative scores indicate that participants gave higher ratings of "No" immediately prior or after the test trials. As can be seen in the figure, the ratings were similar for the AAA and ABA designs, but differed as a function of the instruction. The ratings were also similar across the two test trials. A 2 x 2 x 2 (Instruction x Design x Trial) ANOVA confirmed these impressions by yielding a highly significant main effect for Instruction, $F(1, 44) = 17.04, p < .0005$. No other main effects or interactions were statistically significant, all other $F_s < 3.28$.

 Insert Figure 5 about here

Inspection of the 95% confidence intervals of the mean for each group and trial indicated that the confidence intervals did not encompass zero for any of the revaluation groups, whereas all intervals did encompass zero for the no instruction groups. This difference confirms that there was no change in the ratings between extinction and test in the no instruction groups, whereas participants in the revaluation groups endorsed significantly higher ratings of no relationship between the context and the predictive nature of the CS during the test phase. The results obtained with the participant ratings support the conclusion that participants in the revaluation condition did understand the instructions that were given to the extent that it changed their self-reported perception of the relationship between the context and the predictive meaning the CS. Despite participants indicating that there was no association between the context and the meaning of the CS, significant renewal of conditioned responding remained. There thus appears to be a dissociation between the participants self-report of the relationship between the context and CS and the overt behaviour observed during the test trials.

General Discussion

The present research aimed to investigate whether the renewal effect would be influenced by instructions informing participants that context changes are irrelevant to the predictive relationship between the CS and US. Informing participants prior to conditioning should theoretically lead participants to devalue the role of the context in the predictive relationships between the CS and US. Informing participants immediately prior to the test phase should theoretically lead participants to revalue the role of the context experienced in the prior phases of the experiment. In both cases, the relevance of the context in the CS-US and CS-noUS associations should be reduced. Based on the notion that the renewal effect reflects context dependent

learning during the extinction phase, the instructions were predicted to have the effect of attenuating the renewal of conditioned suppression. However, the present results suggest that the renewal effect was not attenuated and that the instructions had no impact on the participant's behaviour during the test phase. Although the present results are unexpected, the renewal effect has proven to be a difficult effect to attenuate in other research. For instance, renewal has shown to persist even when the extinction treatment is very extensive (Bouton & Swartzentruber, 1989; Rauhut, Thomas, & Ayres, 2001). It has also persisted when extinction treatment is distributed across a variety of contexts (Bouton et al., 2006). The present findings are consistent with this research in suggesting that the renewal effect shows some level of resistance to experimental manipulations that aim to attenuate its occurrence.

One interpretation of the present results is that instructions about the context were ineffective because there were other factors unrelated to the context which caused the renewal effect. Such a conclusion does not seem warranted based on the wealth of experimental evidence suggesting that contextual cues are critical for the renewal effect in animals (see Bouton, 2002; 2004; Bouton & Swartzentruber, 1991). Research with human participants seems to support the animal research. For instance, the magnitude of the ABA renewal effect in the conditioned suppression procedure has been shown to be dependent on the degree of context switch; the larger the context switch the larger the renewal (Havermans et al., 2005). The present research found consistent results when the instructions required subjects to revalue the role of the context across two different conditioning procedures to suggest that the outcomes do not merely reflect the conditioning design used. Moreover, it is not likely that the instructions themselves caused the renewal effect. Such an interpretation might account for the renewal observed in Experiment 2 if the instructions given

immediately prior to test created a type of context change by interrupting the experiment and forming a demarcation between the phases. However, this interpretation would also lead one to expect a renewal effect in the AAA design groups in Experiments 3 and 4, which was not the case. The present results do not appear to reflect that the instructions about the context caused confusion on the part of the participant and that this lead to the suppression of responses. No renewal was found for the CS- in the Context Revaluation group of Experiment 2 or for the CS in the R-AAA and R-NE groups of Experiment 3 despite these groups receiving instructions about the context.

The collection on-line ratings of the participant's evaluation of the relationship between the context and the predictive meaning of the CS in Experiment 4 indicated that participants did attend to the instructions and that the instructions did influence their self-reported perception of the relationship. The evidence suggests that the lack of an effect of the instructions does not reflect that the participants simply ignored the instructions. An alternative, albeit speculative, interpretation of the present results is that non-cognitive processes underlie the failure for the instructions to attenuate renewal. Non-cognitive processes may be implicated if contextual cues increase the activation of the CS-US association following removal from the extinction context. The fact that there is a time pressure involved (the CS duration is only 3-s) may lead participants to adopt a quick non-cognitive outcome of the CS evaluation to guide their behaviour. An alternative to this notion might be that, as proposed by Havermans et al. (2005), participants develop a configural context+CS stimulus and that this configural stimulus becomes associated with the US during acquisition. If such a configural stimulus is formed, the explicit instructions about the contextual cues given at the start of conditioning seemed to be unable to prevent its occurrence.

The present experiment provided instructions that were focused on one extreme, namely that the contextual cues should be devalued in determining the predictive nature of the CS. It would be particularly informative if instructions were also provided in the opposite direction by informing the participants that the contextual cues are highly relevant in determining the predictive nature of the CS¹. Such instructions should serve to increase attention to the contextual changes that occur during the different phases of the learning task to result in an enhanced renewal effect. Vansteenwegen et al. (2006) showed that the renewal effect in humans can be enhanced when a cue that was present during acquisition is also present during test. The use of instructions may provide an alternative means to enhance renewal. Such enhancement would be particularly relevant in the present task as the results suggest that the renewal effect was relatively modest. For instance, in Experiment 3, the renewal of conditioned suppression in an ABA design, while greater than that in a design that did not include any contextual changes (i.e., AAA), was smaller than the suppression observed when no extinction procedure had been implemented (see Figure 3). Instructions that increase the relevance of the contextual manipulations may eliminate the differences between the ABA and no extinction designs. However, whether instructions that highlight the relevance of the context will enhance renewal requires demonstration. The present results suggest that instructions about the relevance of the context have little impact upon the renewal effect. It may be the case that the lack of an effect of explicit instructions is consistent across those that aim to both increase and decrease the relevance of the context.

It is possible that the instructions that devalue the role of contextual cues might have had a larger influence on the renewal effect if they were made more explicit, such as by informing participants that the context is unrelated when the CS is

not followed by the US. This may serve as a stronger manipulation to break down the context dependency of extinction learning. If this is the case, it would suggest that the instructions would need to be very explicit in order to get any attenuation. The implication of the present experiments is that informing participants that the context is irrelevant will not necessarily lead to an attenuation of the renewal effect. The finding suggests that the role of contextual cues during a conditioning procedure that includes an acquisition and extinction phase cannot easily be ignored. This may reflect that after extinction the CS has become ambiguous in that it has two meanings associated with the CS, a CS-US association and a CS-noUS association (Bouton, 2002). The contextual cues serve as the only means by which this ambiguity can be resolved to determine which association is more likely.

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Author Notes

Thanks to Christine McKee, Michelle Hanish, Rae Westbury, and Magnus Reiestad for assistance with data collection and Zoë Fitzgerald for assistance with manuscript preparation. The comments from two anonymous reviewers and Bill Roberts are extremely appreciated. I am grateful to David Johnston for use of the computer program to play the sounds used as part of the context and to Helena Matute for use of the computer program used to present the learning task.

Footnotes

¹ I am grateful for an anonymous reviewer for this suggestion.

Table 1. The design for the acquisition, context exposure, extinction, and test phases for all groups in Experiment 3.

Group	Experimental Phase			
	Acquisition	Context Exposure	Extinction	Test
R-AAA	A[CS-US]	B	A[CS alone]	A[CS alone]
R-ABA	A[CS-US]	A	B[CS alone]	A[CS alone]
R-NE	A[CS-US]	A	B	A[CS alone]
N-AAA	A[CS-US]	B	A[CS alone]	A[CS alone]
N-ABA	A[CS-US]	A	B[CS alone]	A[CS alone]
N-NE	A[CS-US]	A	B	A[CS alone]

Note: The groups are labelled according to the instruction given (R = Context Revaluation, N = No instruction) and the conditioning design (AAA = acquisition, extinction, and test given in same context, ABA = acquisition and test in one context and extinction in the second context,

NE = acquisition and test given in one context but no extinction phase was given). The letters A and B refer to the two contexts. CS refers to the conditional stimulus and US refers to the unconditional stimulus. No CS or US presentations were made during the context exposure in any group or during the extinction phase in the R-NE and S-NE groups.

Figures

Figure 1. Mean conditioned suppression ratio for the Context Devaluation group and the No Instruction group for the CS+ and CS- across the acquisition, extinction, and test phases of Experiment 1. Trials A1, A5, A9, A13, and A17 are acquisition trials, E1, E5, E9, E13, E17, and E21 are extinction trials, and T1 to T3 are test trials.

Figure 2. Mean conditioned suppression ratio for the Context Revaluation group and the No Instruction group for the CS+ and CS- across the acquisition, extinction, and test phases of Experiment 2. Trials A1, A5, A9, A13, and A17 are acquisition trials, E1, E5, E9, E13, E17, and E21 are extinction trials, and T1 to T3 are test trials.

Figure 3. Mean conditioned suppression ratio for each combination of Context Revaluation and No Instructions and AAA, ABA, and NE designs across the acquisition, extinction, and test phases of Experiment 3. Trials A1, A5, A9, A13, and A17 are acquisition trials, E1, E5, E9, E13, E17, and E21 are extinction trials, and T1 to T3 are test trials.

Figure 4. Mean conditioned suppression ratio for each combination of Context Revaluation and No Instructions and AAA and ABA designs across the acquisition, extinction, and test phases of Experiment 4. Trials A1, A5, A9, A13, and A17 are acquisition trials, E1, E5, E9, E13, E17, and E21 are extinction trials, and T1 to T3 are test trials.

Figure 5. Mean rating to the question “Is the meaning of the signal (i.e., whether it is followed by the Martian shield or not) related to what lights and sounds are present in the room?” immediately prior and following the test trials expressed as a change from the rating given immediately following the extinction trials. Negative change values reflect a larger endorsement of the response “Yes” to the question. Error bars depict the standard error of the mean.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5