School of Population Health

Examining Extinction in Evaluative Conditioning

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person where due acknowledgement has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) updated – March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number # HRE2023-0254.

Signature:

Date:

Acknowledgement of Country

We acknowledge that Curtin University works across hundreds of traditional lands and custodial groups in Australia, and with First Nations people around the globe. We wish to pay our deepest respects to their ancestors and members of their communities, past, present, and to their emerging leaders. Our passion and commitment to work with all Australians and peoples from across the world, including our First Nations peoples are at the core of the work we do, reflective of our institutions' values and commitment to our role as leaders in the Reconciliation space in Australia.

Abstract

Evaluative conditioning occurs when a neutral conditional stimulus (CS; e.g., a neutral face) is paired with an unconditional stimulus (US) that can be positive (e.g., a cute dog) or negative (e.g., a sad face). After repeated presentations of the CS and US, the CS acquires the valence of the US. This acquired valence can decrease through extinction when the CS is presented without the US. Past studies have demonstrated that valence can return to the CS after a change in context (i.e., acquisition in context A, extinction in context B, and extinguished responding returns in context A; ABA renewal), but no research has examined how ABA renewal can be reduced in evaluative conditioning. One approach that has been shown to decrease renewal of fear conditioning is presenting unpaired USs in extinction. We investigated whether unpaired USs would reduce renewal in evaluative conditioning. In Experiment 1, one shape was paired with positive pictures (CSp) and another shape was paired with negative pictures (CSu) on screen colour A. During extinction (screen colour B), the standard group had the CSp and CSu presented alone but the additional US group also received 12 unpaired USs (6 positive and 6 negative). For renewal, the CSp and CSu were evaluated on screen colour A. In Experiment 2, we doubled the number of unpaired USs (24; 12 positive and 12 negative) presented during extinction in the additional US group. In Experiment 3, we used a pleasant melody and an unpleasant human scream sound as the USs and presented 24 unpaired USs (12 melody and 12 human scream) in the additional US group across extinction. All experiments showed that conditional valence (CSp evaluated as more pleasant than CSu) and expectancy (CSp rated as more predictive of pleasant pictures than the CSu) was acquired during acquisition. Conditional valence and expectancy significantly reduced during extinction. Renewal was successful, but this was not influenced by the presentations of the additional USs. Overall, presenting unpaired USs in evaluative conditioning does not replicate other paradigm effects, possible mechanisms discussed.

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Introduction

Individuals make a variety of choices in their daily lives such as deciding what products to buy or choosing what books to read. The process in which people determine what they like, and dislike is affected by evaluative conditioning (De Houwer, 2007). Evaluative conditioning is when a neutral conditional stimulus (CS; e.g., neutral face) is paired with an unconditional stimulus (US) which can be positive (e.g., a cute dog) or negative (e.g., a sad face). After repeated presentations of the CS and US, the CS starts to acquire the valence of the US. For example, if a liked celebrity was seen wearing new shoes in an advertisement, those shoes may be evaluated as more pleasant or if you saw a stranger with a group of people you do not like, you may develop a dislike towards the stranger. Evaluative conditioning has also been shown to work with a diverse set of stimuli that include sounds, pictures, flavours, and odours (Hofmann et al., 2010; Moran & Bar-Anan, 2013). Once a CS has acquired the valence of the US through evaluative conditioning, this valence can be reduced through a procedure known as extinction, which is when the CS is repeatedly presented without the US (Hofmann et al., 2010). Extinction has been shown to work in evaluative conditioning, however, there have been some debates on whether evaluative conditioning is resistant to extinction (see Hofmann et al., 2010).

While extinction may temporarily reduce the valence of the CS, the extinguished responding can return. In a classical conditioning paradigm, there are three common methods of extinguished responding returning which are spontaneous recovery, renewal, and reinstatement (Bouton, 2002). Spontaneous recovery occurs when extinguished responding returns after the extinguished CSs are presented after a delay. Renewal occurs when acquisition takes place in one context (i.e., context A), extinction takes place in a different context (i.e., context B), and extinguished responding returns in the original context (i.e., context A) or in a context different from acquisition and extinction (i.e., context C). Moreover, extinguished responding reappears in reinstatement after the US is presented without the CS unexpectedly after extinction. Although the return of responding has been shown in a classical conditioning paradigm, this was only recently demonstrated in evaluative conditioning by Luck and Lipp (2020b).

Luck and Lipp (2020b) assessed whether evaluative learning would re-emerge after spontaneous recovery, renewal, and reinstatement. There were three different streams in the study where spontaneous recovery, renewal and reinstatement were tested in separate

experiments. In acquisition, one shape (e.g., triangle) was paired with positive pictures (e.g., happy families; CSp) and a different shape was paired with negative pictures (e.g., sad children; CSu). Conditional valence (i.e., the CSp was rated as more pleasant than the CSu) and conditional expectancy (i.e., the CSp was more predictive of pleasant pictures than the CSu) was acquired in all experiments. During extinction, the CSp and the CSu were presented alone, however, for the renewal experiment, this was done on a different screen colour (colour B). Conditional valence and expectancy decreased in all experiments. For reinstatement, positive and negative pictures were presented randomly after extinction and then the CSs were tested again. During spontaneous recovery, the CSs were tested 24 hours after extinction. Finally, renewal occurred when the CSs were assessed on the original screen colour (colour A). Conditional expectancy returned after extinction in all experiments, however, conditional valence increased after extinction in the renewal and reinstatement experiments, but unexpectedly did not increase after extinction in the spontaneous recovery experiment. Therefore, extinguished responding returning in evaluative conditioning was demonstrated in reinstatement and renewal but not in spontaneous recovery.

Theory of Extinction

Observing extinguished responding returning after reinstatement and renewal, can be explained by Bouton's theory of extinction (2002) who states that extinguished responding returns because the original learning of the CS-US association has not been removed during extinction. Instead, during extinction, a new type of learning is formed in which the individual learns that the CS is not associated with the US anymore (CS- no US association). However, the original CS-US association is not erased which means it can be triggered by certain cues such as the change in context (i.e., renewal). Since the original CS-US association remains, extinguished responding can reappear. It is not clear, however, why conditional valence did not return after spontaneous recovery. Extinguished responding returning is a big issue because negative attitudes towards social groups (e.g., prejudicial attitudes) may not be entirely removed during extinction training (Olson & Fazio, 2006). Understanding how extinction can be strengthened may help develop interventions in the future that focus on reducing the return of negative attitudes. Currently, there is no research examining how the return of responding can be reduced in evaluative conditioning but despite this, there have been progressive steps in understanding how the return of responding operates in other learning paradigms such as fear and appetitive conditioning. One promising technique that has shown to significantly decrease the return of fear in multiple human

studies is presenting unpaired USs in extinction (Lipp et al., 2021; Thompson et al., 2018; Vervliet et al., 2010).

Research Using Unpaired USs

Van den Akker et al. (2015) examined the effects of unpaired USs on reacquisition (i.e., a manipulation that involves pairing the CS and US together after extinction to test if the learning is acquired rapidly) in appetitive conditioning. In their study, the CS was a jewellery box (CS+) paired with a chocolate mousse (US) and, a second box (known as the CS-), contained no chocolate mousse. During extinction, the unpaired group had two unpaired USs which were presented in the intertrial interval (i.e., the space between the CS offset and the next CS onset) and the standard extinction group contained no USs. The results indicated that the unpaired group showed slower reacquisition compared to the standard extinction group in US expectancy, but this was not shown in the desire ratings. Additionally, Thompson et al. (2018) found similar results using unpaired USs in a fear conditioning paradigm. Pictures of animals (e.g., bird and fish) were used as the CS and an electric shock was used as the US (i.e., the CS+ was paired with the electric shock and the CS- was presented alone). Five unpaired USs were presented during the middle of the intertrial interval in extinction. They found that the unpaired group showed reduced conditional skin conductance responses for spontaneous recovery and reacquisition relative to the standard extinction group (i.e., spontaneous recovery and reacquisition of fear was slower in the unpaired group).

Furthermore, three studies have demonstrated that ABA renewal of fear can be attenuated using unpaired USs (Lipp et al., 2021; Lipp et al., 2024; Vervliet et al., 2010). Vervliet et al. (2010) found that differential electrodermal responding was reduced in the unpaired group that contained six unpaired USs but the results for US expectancy were unclear, potentially due to the low sample size. Lipp et al. (2021) extended these findings by reducing the reacquisition and the renewal of fear in a larger sample. The stimuli were similar to Thompson et al. (2018), but the US was an aversive sound. Renewal was tested by using different screen colours. For example, acquisition occurred on one screen colour (e.g., blue) extinction took place on a different screen colour (e.g., yellow) and renewal used the original screen colour (e.g., blue). The authors used five unpaired USs during extinction which was consistent with Thompson et al. (2018). Differential electrodermal responding was present in the standard extinction group but not in the unpaired group for renewal and reacquisition (i.e., renewal and reacquisition of fear decreased in the unpaired group). To explain these results,

Lipp et al. (2024) tested whether the effects of unpaired USs in ABA renewal could be explained by enhancing extinction learning (i.e., strengthening the CS-no US association during extinction). The Rescorla and Wagner (1972) model suggests that when a US is presented without the CS then the context is likely to acquire associative strength (context conditioning). For instance, during extinction, if an electric shock (US) is presented without the CS, the context becomes more dangerous and therefore when the CS is presented alone in this context it is more surprising for the individual and should enhance extinction learning and thus reduce the return of responding.

Using a similar design as Lipp et al. (2021), Lipp et al. (2024) tested this possibility by adding a third group to the experiment. In their study, there was a signalled group in which a third novel CS (CSC) was presented with the US during extinction (i.e., CSC was presented, followed by a US), an unsignalled group (unpaired USs were presented during the intertrial interval), and the standard extinction group. Presenting the CSC during extinction should reduce context conditioning as the CSC is a stronger predictor for the US than the context, resulting in the extra extinction learning acquired by the CS+ to be reduced (Lipp et al., 2024; Rescorla, 1969) if context conditioning is the mechanism responsible for the additional US effect. The results from the experiment indicated that renewal of fear was reduced in both the signalled and unsignalled groups which meant that presenting CSCs during extinction did not affect extinction learning in the signalled group (Lipp et al., 2024). This suggests that the mechanism may not be context conditioning, however, another popular explanation for the effects of unpaired USs is the general arousal account. The general arousal account shows that maintaining a certain level of arousal during extinction (Waters et al., 2018; Waters et al., 2021) improves attention to the CSs and consequently, may reduce renewal (Hockey, 1970; Lipp et al., 2024). Nevertheless, it is still unclear how unpaired USs work in fear conditioning.

Although the mechanism is unclear, the unpaired US manipulation shows encouraging signs that it can be used as a suitable approach to diminish the return of responding (Lipp et al., 2024). Including unpaired USs across extinction has been shown to decrease renewal, spontaneous recovery, reacquisition of fear and appetitive responses compared to standard extinction groups (Lipp et al., 2021; Lipp et al., 2024; Thompson et al., 2018; van den Akker et al., 2015). The USs have differed between the studies but also the number of unpaired USs in extinction have varied across studies which demonstrates the robustness of the unpaired

USs (Lipp et al., 2021; Vervliet et al., 2010). Thus, this approach may also be used to reduce extinguished responding returning in evaluative conditioning.

Current Study

The present study focused on presenting unpaired USs during extinction in evaluative conditioning using an ABA renewal design to examine whether we could replicate the results from fear conditioning (Lipp et al., 2021). There were three stages in the experiment which were acquisition, extinction and renewal. US expectancy and CS valence were used across all stages to measure acquisition, extinction and renewal. One screen colour (e.g., blue) was used during acquisition and renewal, another screen colour (e.g., grey) was used during extinction. In acquisition (e.g., blue), one CS was paired with positive pictures (CSp) and another CS was paired with negative pictures (CSu). During extinction (e.g., grey), the CSp and CSu were presented without the US in the standard group but the additional US group included 12 random presentations of the US (6 positive and 6 negative pictures) throughout extinction. In renewal, the screen colour changed back to the original screen colour (e.g., blue). We hypothesised that conditional valence (i.e., CSp rated more pleasant than the CSu) and conditional expectancy (i.e., the CSp would be more predictive of pleasant pictures than the CSu) would be present in acquisition. In extinction, we expected conditional valence and conditional expectancy to decrease. Lastly, we hypothesised that the re-emergence of conditional valence and expectancy in renewal would be smaller in the additional US group compared to the standard extinction group (i.e., less renewal in the additional US group).

Experiment 1

Method

Participants

One hundred and forty-four participants (69 male: 74 female: 1 non-binary) between the ages of 18 and 65 (*M* = 29.62, *SD* = 13.45) voluntarily participated in the current study. One participant was not included in the study due to a computer error preventing them from completing the experiment (final sample consisted of 144 participants). Convenience sampling was used to recruit psychology students at Curtin University (students received course credit) and volunteers from the researcher's network (general volunteers received no compensation). An a priori G power 3.1 analysis using an analysis of variance (ANOVA) F

test: repeated measure, within-between interaction (two groups; two measurement points [conditional response at last extinction point; conditional response at renewal test]; nonsphericity correction: one) revealed that 128 participants was required to detect a medium Cohen's effect size ($f = 0.25$) with power at 80%, alpha level = 0.05 (Cohen, 1988). Participants were randomly allocated to the additional US group ($n = 70$) or the standard extinction group ($n = 74$). The research was approved by the Curtin University Human Research Ethics Committee (HRE2023-0254).

Apparatus and Measures

The program used to collect the data was Inquisit 6. The screen colours were grey (RGB; 120, 120, 120) and blue (RGB; 65,140,210) for the experiment. The sequence could either be grey blue grey or blue grey blue and this was counterbalanced between participants. The CSs were pictures of either a square, triangle, circle or a diamond. The participants saw two of these shapes, one shape paired with positive pictures (CSp) and the other shape with negative pictures (CSu), and this was counterbalanced between all participants. The positive and negative pictures were taken from the International Affective Picture System (Lang et al., 2008). The 6 positive US pictures (codes: 1460, 1710, 2154, 2340, 5825, 5833) included subjects such as nature scenes, animals and happy families; mean valence rating = 7.92 (1 = low pleasure and 9 = high pleasure); mean arousal rating = 5.22 (1 = low arousal and 9 = high arousal). The 6 negative pictures (codes: 9560, 9340, 9295, 9220, 2800, 2703) included subjects such as sick animals, rubbish and starving children; mean valence rating = 2.32; mean arousal rating = 4.93. The trial sequence for extinction consisted of six blocks and each block contained 6 CSp and 6 CSu trials. Twelve unpaired USs (6 positive and 6 negative) were spread across extinction for the additional group. There was a USp and a USu presented in each block with fixed positions, and no two consecutive blocks had the same order of the unpaired USs. The CS trials were pseudorandomised with no more than 8 consecutive CS trials in each block. A Likert scale from 1-9 (1 = unpleasant and 9 = pleasant) was used to assess CS and US valence (Luck & Lipp, 2020b). US expectancy was measured by asking participants to predict what kind of pictures will follow the shapes (CS) on a Likert scale from 1-7 (1 = always unpleasant, 4 = no pictures, 7 = always pleasant). Demographics (age and gender) were collected after the experiment. Participants were asked whether or not they noticed the screen colour change during the experiment (manipulation check). Participants had to identify which shape was paired with the positive pictures, and which shape was paired with the negative pictures (contingency question).

Procedure

Participants first read the information sheet and signed the consent form. The participants were assigned to the standard extinction group, or the additional US group based on their arrival to the laboratory (one after the other) and were seated in front of a computer. The experiment included a baseline CS valence assessment, acquisition phase, extinction phase, renewal phase and a US valence assessment. Before the experiment started, a baseline CS valence assessment was completed where participants evaluated how pleasant or unpleasant the shapes were. During acquisition (screen colour A), the CS was presented on the screen for 2 seconds, followed by the US for 2 seconds and then a blank screen for 8 seconds (intertrial interval). After 24 trials (12 positive and 12 negative CS-US pairings), both groups completed a mid-acquisition test. In the mid-acquisition test, CS valence and US expectancy were measured. The participants continued the acquisition phase with another 24 trials and completed the CS valence and US expectancy measures at the end of acquisition. In extinction (screen colour B), participants went through 72 trials. For the standard extinction group, the CS was presented without the US (i.e., the CS was presented for 2 seconds followed by the intertrial interval). For the additional US group, the CS was presented without the US but there were 12 unpaired US (6 positive and 6 negative pictures) presentations during the middle of the intertrial interval (i.e., US was presented for 2 seconds) and these were spread out evenly across extinction. Both groups completed the CS valence and US expectancy assessments in the middle of extinction (after 36 trials) and at the end of extinction (after 72 trials). For renewal, the screen colour changed back to the original colour (screen colour A) used in acquisition and participants completed CS valence and US expectancy assessments for both the CSp and CSu. US valence was assessed after renewal where participants rated how pleasant or unpleasant the 12 US pictures were. Finally, a paper questionnaire was handed out where participants were asked about their demographics (age and gender), if they saw the screen colour change and which shape was paired with pleasant pictures and unpleasant pictures.

Data Preparation and Analyses

Pillai trace values of the multivariate solution with an alpha cutoff of .05 were used for the mixed model ANOVA's in SPSS statistics. The term conditional valence refers to a significant difference between the CSp and CSu valence ratings in the direction of conditioning (i.e., CSp rated more pleasant than the CSu) and the term conditional expectancy refers to a significant difference between the expectancy scores for the CSp and

CSu in the direction of conditioning (i.e., CSp is more predictive of pleasant pictures than the CSu).

Results

Preliminary Checks

An independent samples *t*-test confirmed the additional US ($M = 30.54$, $SD = 13.99$) and standard extinction group ($M = 28.76$, $SD = 12.96$) did not differ in age, $t(141) = 0.79$, $p = .431$). Three separate chi-square tests were used to test the difference between the groups for detecting the screen colour change (pass to fail ratio), contingency assessment (pass to fail ratio) and gender. Pass to fail ratio for the screen colour change detection (additional US: 67:3; standard extinction: 65:9) did not differ between the two groups $X^2(1, N = 144) = 2.92$, $p = .087$). There was no significant difference between the two groups for the contingency assessment pass to fail ratio (additional US: 67:3; standard extinction: 67:7), $X^2(1, N = 144) = 1.49$, $p = .222$. The male to female to non-binary gender ratio did not differ between the two groups (additional US: 37:33:0; standard extinction: 32:41:1), $X^2 (2, N = 144) = 2.12$, $p = .347$. The six pleasant pictures (USp) and the six unpleasant pictures (USu) were averaged into mean scores and these scores were subjected to a mixed model ANOVA. A main effect was shown for the US type, $F(1, 142) = 2496.55$, $p < .001$, $\eta p^2 = .946$, which confirmed that pleasant pictures ($M = 7.96$, $SD = 0.84$) were evaluated more pleasant than the unpleasant pictures ($M = 1.94$, $SD = 0.80$). The main effect of group, $F(1, 142) = 2.70$, $p = .103$, $\eta p^2 = .019$, and the US $\times$ Group interaction, $F(1, 142) = 0.54$, $p = .463$, $\eta p^2 = .004$, were not significant confirming that evaluations of the USs did not differ between the standard extinction (USp, $M = 8.05$, $SD = 0.83$; USu, $M = 1.95$, $SD = 0.85$) and additional US group (USp, $M = 7.86$, $SD = 0.85$; USu, $M = 1.93$, $SD = 0.75$). Participants who failed the contingency question and screen colour change check were included in the current analysis as the pattern of results was very similar when they were removed.

Acquisition
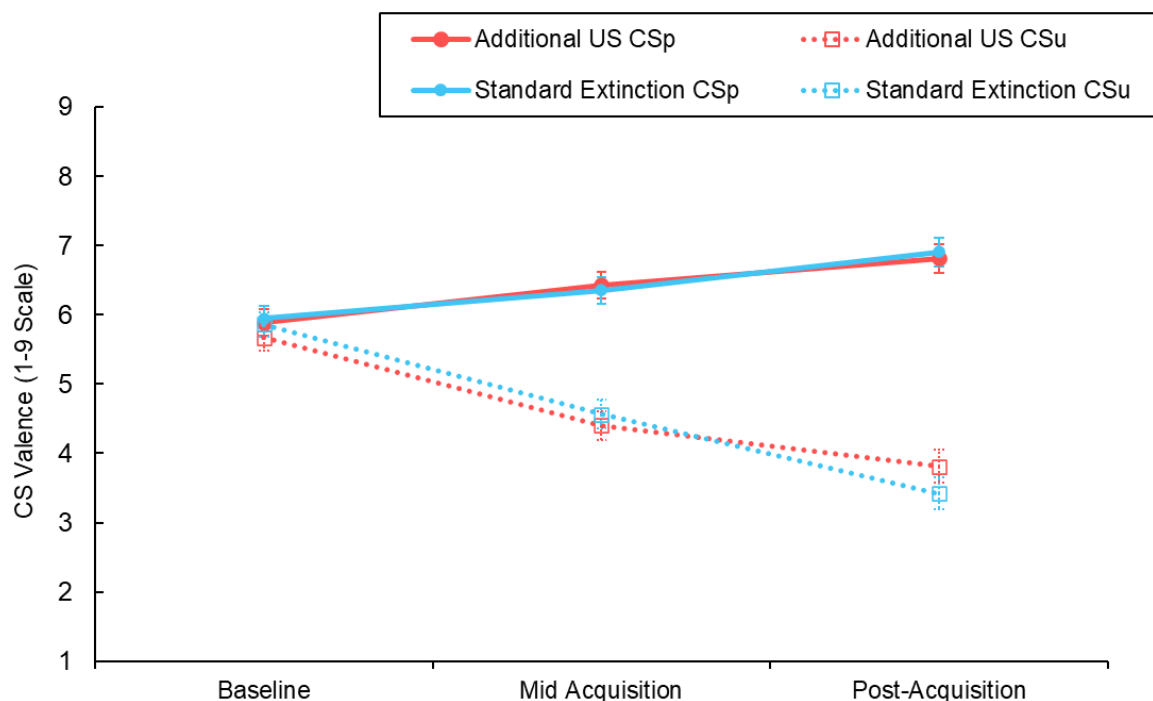
CS Valence

The CS valence ratings for the additional US and standard extinction group are presented in Figure 1. A 2 CS (CSp and CSu) $\times$ 3 Rating Time (baseline, mid-acquisition and post-acquisition) $\times$ 2 Group (additional US and standard extinction) mixed model ANOVA was tested. Main effects of CS, $F(1, 142) = 106.77$, $p < .001$, $\eta p^2 = .429$, and rating time, $F(2,$

141) = 18.30, $p < .001$, $\eta p^2 = .206$, were moderated by a CS × Rating Time interaction, $F(2,$ 141) = 70.56, $p < .001$, $\eta p^2 = .500$. Follow up analyses revealed at baseline, $F(1, 142) = 1.86$, $p = .175$, $\eta p^2 = .013$, there were no significant difference between the evaluations of the CSp and CSu. At mid-acquisition, $F(1, 142) = 71.35$, $p <. 001$, $\eta p^2 = .334$, and post-acquisition, $F(1, 142) = 135.47$, $p < .001$, $\eta p^2 = .488$, the CSp was rated as more pleasant than the CSu. The size of conditioning was analysed using difference scores for CS valence ratings (i.e., CSp scores subtracted from the CSu scores) at baseline, mid-acquisition and post-acquisition. These difference scores were subjected to the same ANOVA as above but without the CS factor. Conditional valence increased from baseline to mid-acquisition, $p < .001$, and increased from mid-acquisition to post-acquisition, $p < .001$. The other omnibus effects were non-significant, $F \leq 1.78$, $p \geq .172$, $\eta p^2 \leq .025$.
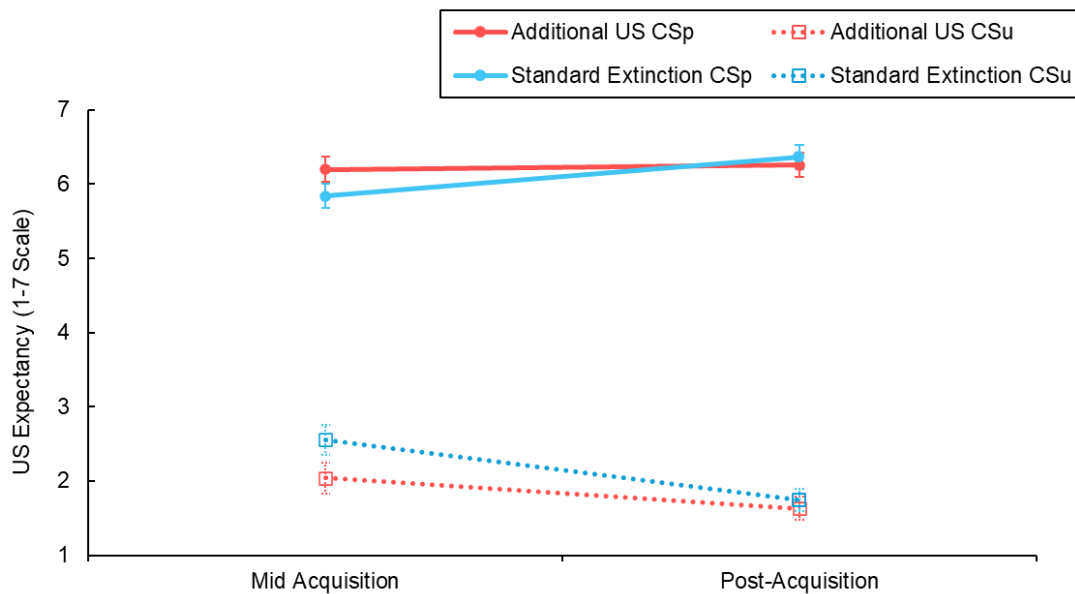
Figure 1

CS Valence During Acquisition

Note. CS valence ratings at baseline, mid-acquisition and post-acquisition. The standard error of mean is presented through the error bars.
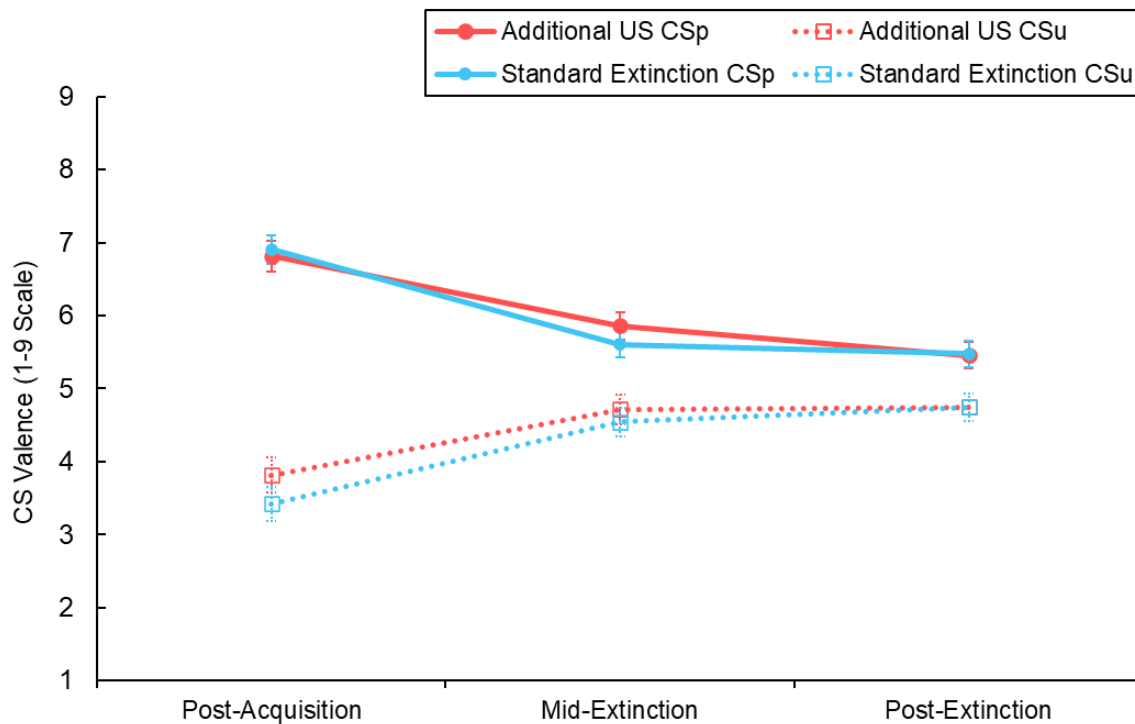
US Expectancy

The US expectancy ratings for the additional US and standard extinction group are presented in Figure 2. Main effects of CS, $F(1, 142) = 477.20$, $p < .001$, $\eta p^2 = .771$, and rating time, $F(1, 142) = 5.65$, $p = .019$, $\eta p^2 = .038$, a CS × Rating Time interaction, $F(1, 142) = 20.24$, $p < .001$, $\eta p^2 = .125$, and a CS × Rating Time × Group interaction, $F(1, 142) = 4.64$, $p = .033$, $\eta p^2 = .032$, were obtained. Follow up analyses of the CS × Rating Time × Group interaction revealed that the expectancy scores were higher for the CSp than the CSu in the additional US group at mid-acquisition, $F(1, 142) = 150.64$, $p < .001$, $\eta p^2 = .515$, and at post-acquisition, $F(1, 142) = 278.82$, $p < .001$, $\eta p^2 = .663$. The same occurred in the standard extinction group at mid-acquisition, $F(1, 142) = 99.37$, $p < .001$, $\eta p^2 = .412$, and at post-acquisition, $F(1, 142) = 293.87$, $p < .001$, $\eta p^2 = .674$. The size of conditioning was analysed by using difference scores for US expectancy ratings (i.e., expectancy scores for the CSp subtracted from the CSu expectancy scores) at mid-acquisition and post-acquisition. These difference scores were subjected to the same ANOVA as above but without the CS factor. Conditional expectancy increased from mid-acquisition to post-acquisition in the standard extinction group, $F(1, 142) = 22,78$, $p < .001$, $\eta p^2 = .138$, whereas, the additional US group showed no change from mid-acquisition to post-acquisition, $F(1, 142) = 2.67$, $p = .104$, $\eta p^2 = .018$. However, there was no difference in the size of conditioning between the standard extinction and additional US group at post-acquisition, $F(1, 142) < 0.01$, $p = .986$, $\eta p^2 < .001$, confirming that the groups had an equivalent level of conditioning at post-acquisition. The other omnibus effects were non-significant, $F \leq 1.33$, $p \geq .251$, $\eta p^2 \leq .009$.

Figure 2

US Expectancy During Acquisition

Note. US expectancy ratings at mid-acquisition and post-acquisition. The standard error of mean is presented through the error bars. Ratings above four shows that participants expected a pleasant picture and ratings less than four indicates that participants expected an unpleasant picture.

Extinction

CS Valence

The CS valence ratings for the additional US and standard extinction group are presented in Figure 3. A main effect for CS, $F(1, 142) = 106.73$, $p < .001$, $\eta p^2 = .429$, and a CS × Rating Time interaction, $F(2, 141) = 41.28$, $p < .001$, $\eta p^2 = .369$, were found. Follow up analyses of the CS × Rating Time interaction revealed that the CSp was evaluated more pleasant than the CSu at post-acquisition, $F(1, 142) = 135.47$, $p < .001$, $\eta p^2 = .488$, mid-extinction, $F(1, 142) = 29.53$, $p < .001$, $\eta p^2 = .172$, and post-extinction, $F(1, 142) = 20.22$, $p < .001$, $\eta p^2 = .125$. Conditional valence decreased from post-acquisition to mid-extinction, $p < .001$, but did not change from mid-extinction to post-extinction, $p = .054$. The other omnibus effects were non-significant, $F \leq 1.28$, $p \geq .282$, $\eta p^2 \leq .018$.

Figure 3

CS Valence During Extinction

Note. CS valence ratings at post-acquisition, mid-extinction and post-extinction. The standard error of mean is presented through the error bars.

US Expectancy

The US expectancy ratings for the additional US and standard extinction group are presented in Figure 4. Main effects of CS, $F(1, 142) = 294.55$, $p < .001$, $\eta p^2 = .675$, and rating time, $F(2, 141) = 3.54$, $p = .032$, $\eta p^2 = .048$, were moderated by a CS × Rating Time interaction, $F(2, 141) = 129.34$, $p < .001$, $\eta p^2 = .647$. Follow up analyses of the CS × Rating Time interaction revealed that expectancy scores were higher for the CSp than the CSu at post-acquisition, $F(1, 142) = 572.28$, $p < .001$, $\eta p^2 = .801$, mid-extinction, $F(1, 142) = 44.83$, $p < .001$, $\eta p^2 = .240$, and post-extinction, $F(1, 142) = 14.17$, $p < .001$, $\eta p^2 = .091$. Conditional expectancy decreased from post-acquisition to mid-extinction, $p < .001$. A further decrease of conditional expectancy was shown from mid-extinction to post-extinction, $p = .008$. The remaining omnibus effects were non-significant, $F \leq 1.98$, $p \geq .162$, $\eta p^2 \leq .014$.

Figure 4

US Expectancy During Extinction

Note. US expectancy ratings at post-acquisition, mid-extinction and post-extinction. The standard error of mean is presented through the error bars. Ratings above four shows that participants expected a pleasant picture and ratings less than four indicates that participants expected an unpleasant picture.
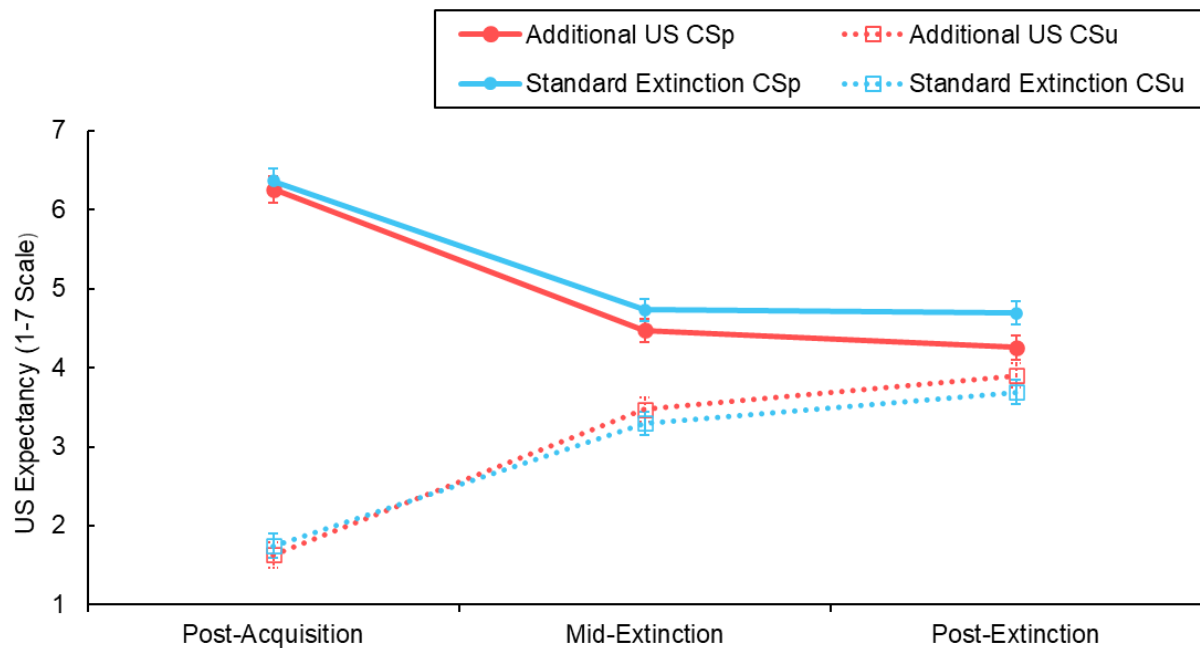
Renewal

CS Valence

The CS valence ratings for the additional US and standard extinction group are presented in Figure 5. Main effects for CS, $F(1, 142) = 33.29$, $p < .001$, $\eta p^2 = .190$, and rating time, $F(1, 142) = 4.05$, $p = .046$, $\eta p^2 = .028$, were moderated by a CS × Rating Time interaction, $F(1, 142) = 6.90$, $p = .010$, $\eta p^2 = .046$. Follow up analyses of the CS × Rating Time interaction revealed that the CSp was rated as more pleasant than the CSu at post-extinction, $F(1, 142) = 20.22$, $p < .001$, $\eta p^2 = .125$ and renewal, $F(1, 142) = 33.87$, $p < .001$, $\eta p^2 = .193$. Conditional valence increased from post-extinction to renewal, $p = .010$,

indicating successful renewal but there were no significant differences between the groups. The other omnibus effects were non-significant, $F \leq 0.76$, $p \geq .386$, $\eta p^2 \leq .005$.

Figure 5

CS Valence During Renewal
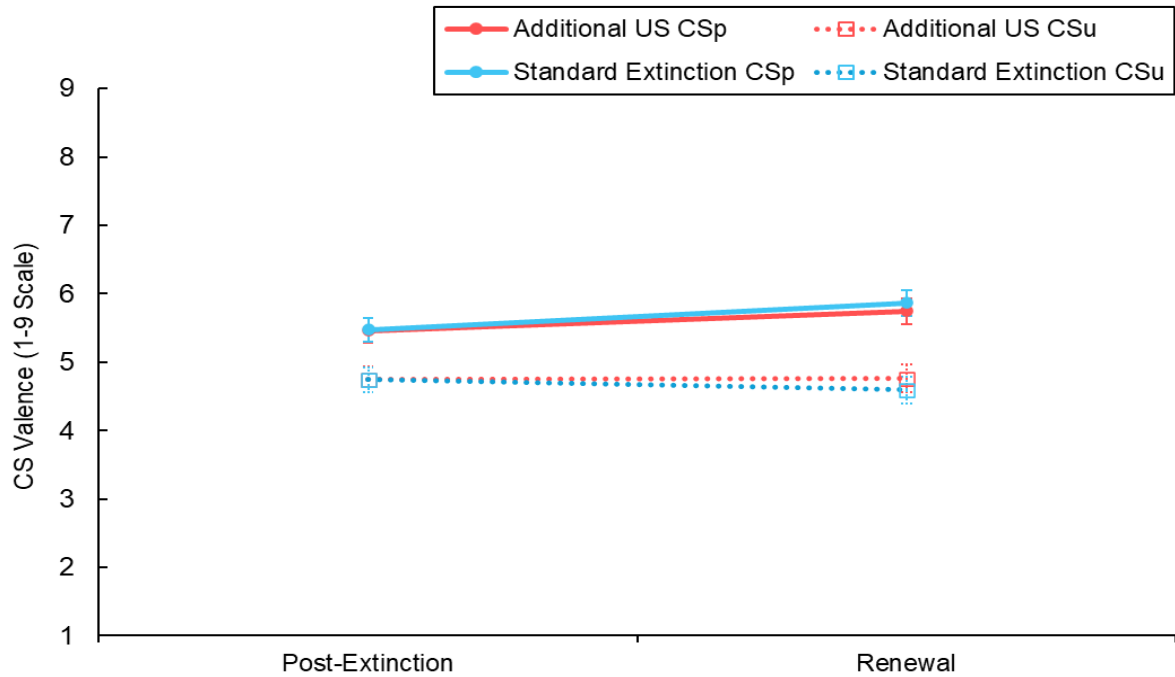
Note. CS valence ratings at post-extinction and renewal. The standard error of mean is presented through the error bars.

US Expectancy

The US expectancy ratings for the additional US and standard extinction group are presented in Figure 6. Main effects of CS, $F(1, 142) = 53.03$, $p < .001$, $\eta p^2 = .272$, and CS × Rating Time interaction, $F(1, 142) = 23.36$, $p < .001$, $\eta p^2 = .141$, were found. Follow up analysis of the CS × Rating Time interaction showed that the expectancy scores for the CSp was higher than for the CSu at post-extinction, $F(1, 142) = 14.17$, $p < .001$, $\eta p^2 = .091$, and renewal, $F(1, 142) = 68.71$, $p < .001$, $\eta p^2 = .326$. Conditional expectancy increased from post-extinction to renewal (i.e., renewal occurred), $p < .001$, and this effect was not

moderated by group. The remaining omnibus effects were non-significant, $F \leq 1.60$, $p \geq .209$, $\eta p^2 \leq .011$.

Figure 6

US Expectancy During Renewal

Note. US expectancy ratings at post-extinction and renewal. The standard error of mean is presented through the error bars. Ratings above four shows that participants expected a pleasant picture and ratings less than four indicates that participants expected an unpleasant picture.
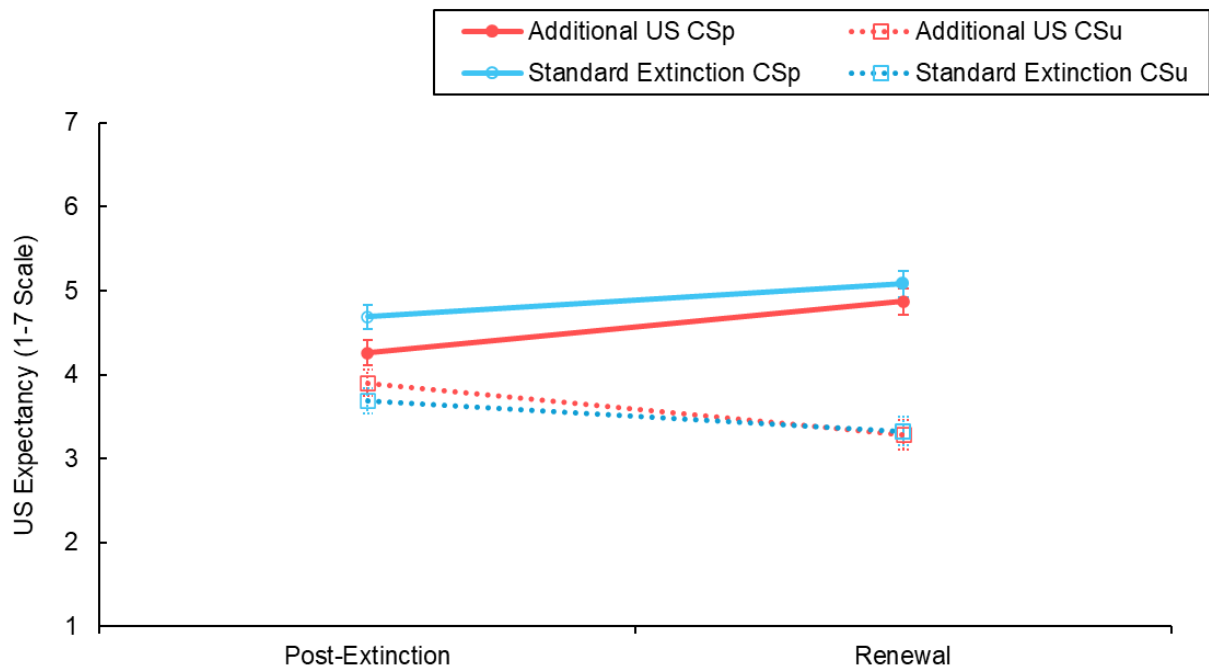
Discussion

In Experiment 1, we tested whether additional USs presented during extinction would decrease the renewal of evaluative learning. In acquisition, conditional valence was present for the standard extinction group and the additional US group but interestingly, we found differences between conditional expectancy in the additional US and the standard extinction group. Conditional expectancy increased from mid-acquisition to post-acquisition for the standard extinction group, but no change was observed in the additional US group.

Nonetheless, we did not find conditional expectancy to differ between the groups at post-acquisition which indicates that the size of conditional expectancy was similar for both groups. As predicted, conditional valence and expectancy decreased during extinction. Lastly, we observed a return of conditional valence and expectancy in renewal (i.e., renewal occurred) but this was not moderated by group.

Our finding that unpaired USs did not have a significant effect during renewal was not in line with previous fear conditioning literature (Lipp et al., 2021). One possible explanation for this finding is that we did not present a sufficient number of unpaired USs in the current study. For example, Lipp et al. (2021) and Thompson et al. (2018) used 5 unpaired USs for 24 CS+ trials in extinction, whereas we included 12 unpaired USs (6 positive and 6 negative) for 72 CS trials and this comparison indicates that we have a lower ratio of unpaired USs to CS trials in our experiment. Moreover, by increasing the number of unpaired USs for the additional US group, we would have a similar ratio of unpaired USs to CS trials relative to previous fear studies (Lipp et al., 2021; Thompson et al., 2018). In Experiment 2, we examined whether increasing the number of unpaired USs in extinction would reduce renewal in the additional US group. We kept the general procedure the same, however, doubled the number of unpaired USs presented for the additional US group (24 total US presentations). We hypothesised that conditional valence and conditional expectancy would be present in acquisition. In extinction, we expected conditional valence and conditional expectancy to decrease. Lastly, we hypothesised that the re-emergence of conditional valence and expectancy in renewal would be smaller in the additional US group compared to the standard extinction group (i.e., less renewal in the additional US group).

Experiment 2

Method

Participants

One hundred and forty-one participants (35 male; 104 female; 2 non-binary) between the ages of 18 and 49 ($M = 22.50$, $SD = 5.43$) voluntarily participated in the experiment. Participants were recruited from the undergraduate psychology course (students received course credit) at Curtin University or via the researchers' network (general volunteers received no compensation). There were no participants excluded from the study. The power analysis was the same as the previous experiment, but we recruited additional participants to

replace those who failed the screen colour manipulation check. This study was approved by the Curtin University Human Research Ethics Committee. Participants were randomly allocated to the additional US ($n = 72$) or the standard extinction group ($n = 69$).

Apparatus and Measures

The apparatus and measures were the same as Experiment 1.

Procedure

In extinction, 24 unpaired presentations (12 positive and 12 negative) of the US were presented in the additional US group. The standard extinction group did not receive unpaired US presentations. The trial sequence for extinction was modified to include 24 unpaired USs for the additional US group. There were 4 USs (2 positive and 2 negative pictures) presented in each block (i.e., 4 USs were presented for every 12 trials). For each block, the four unpaired USs were presented during different intertrial intervals, and no two consecutive blocks had the same order of the unpaired USs. There were two different structures for the trial sequence which counterbalanced whether the CSp or CSu was presented first during each phase of conditioning. In each block, there were no more than four consecutive CSp or CSu trials. The remainder of the procedure was the same as in Experiment 1.

Data Preparation and Analyses

The data preparation and analyses were the same as in Experiment 1.

Results

Preliminary checks

An independent samples t-test confirmed that the additional US ($M = 22.57$, $SD = 5.01$) and standard extinction group ($M = 22.43$, $SD = 5.88$) showed no differences in age, $t(139) = 0.15$, $p = .884$. The pass to fail ratio for the manipulation check (screen colour) did not differ between the additional US (64:8) and standard extinction group (64:5), $X^2(1, N = 141) = 0.63$, $p = .428$. The male to female to non-binary gender ratio did not differ between the additional US (18:54:0) and standard extinction groups (17:50:2), $X^2(2, N = 141) = 2.12$, $p = .347$. For the contingency assessment, the additional US (68:4) and standard extinction (68:1) group showed no significant differences in the pass to fail ratio. $X^2(1, N = 141) = 1.74$, $p = .188$. When examining whether group differences were present in US valence, a main effect of US type, $F(1, 139) = 1952.60$, $p < .001$, $\eta p^2 = .934$, and a US type × Group

interaction, $F(1, 139) = 4.48$, $p = .036$, $\eta p^2 = .031$, were detected. Follow up analyses indicated that the USp were evaluated as more pleasant than the USu in the additional US group (USp: $M = 7.69$, $SD = 0.90$; USu: $M = 2.19$, $SD = 0.82$) , $F(1, 139) = 904.23$, $p < .001$, $\eta p^2 = .867$, and the standard extinction group (USp: $M = 8.02$, $SD = 0.86$; USu: $M = 1.98$, $SD = 0.82$), $F(1, 139) = 1049.75$, $p < .001$, $\eta p^2 = .883$. However, the evaluations of the USp were more pleasant in the standard extinction group compared to the additional US group, $F(1, 139) = 5.20$, $p = .024$, $\eta p^2 = .036$, but the evaluations of the USu did not differ between the groups, $F(1, 139) = 2.39$, $p < .125$, $\eta p^2 = .017$. The main effect for group was non-significant, $F(1,139) = 1.09$, $p = .298$, $\eta p^2 = .008$.
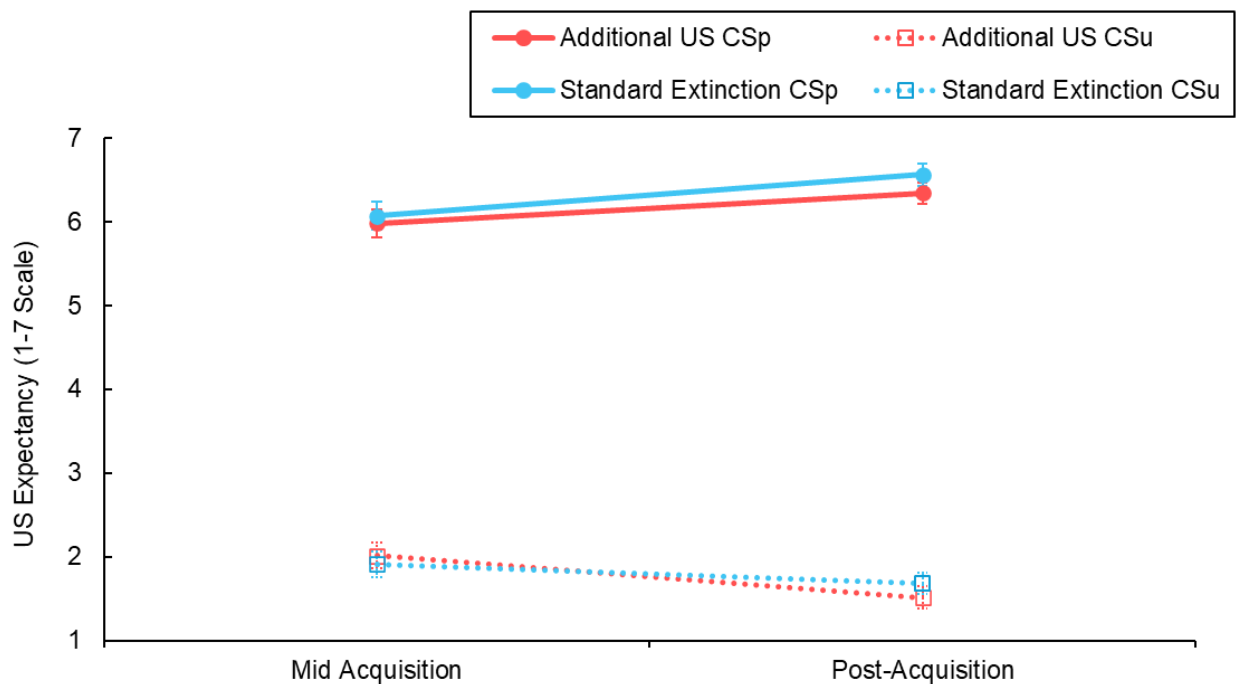
Acquisition

CS Valence

CS valence ratings for the additional US group and standard extinction group are presented in Figure 7. Main effects of CS, $F(1, 139) = 187.38$, $p < .001$, $\eta p^2 = .574$, and rating time, $F(2, 138) = 5.60$, $p = .005$, $\eta p^2 = .075$, were moderated by a CS × Rating Time interaction, $F(2, 138) = 102.76$, $p < .001$, $\eta p^2 = .598$. Follow up analyses of the CS × Rating Time interaction revealed at baseline, $F(1, 139) = 0.34$, $p = .560$, $\eta p^2 = .002$, there were no differences between the CSp and CSu. During mid-acquisition, $F(1, 139) = 151.93$, $p < .001$, $\eta p^2 = .522$, and post-acquisition, $F(1, 139) = 210.48$, $p < .001$, $\eta p^2 = .602$, the CSp was evaluated as more pleasant than the CSu. Conditional valence increased from baseline to mid-acquisition, $p < .001$, and increased from mid-acquisition to post acquisition, $p < .001$. The remaining omnibus effects were non-significant, $F \leq 1.42$, $p \geq .236$, $\eta p^2 \leq .010$.

Figure 7

CS Valence During Acquisition
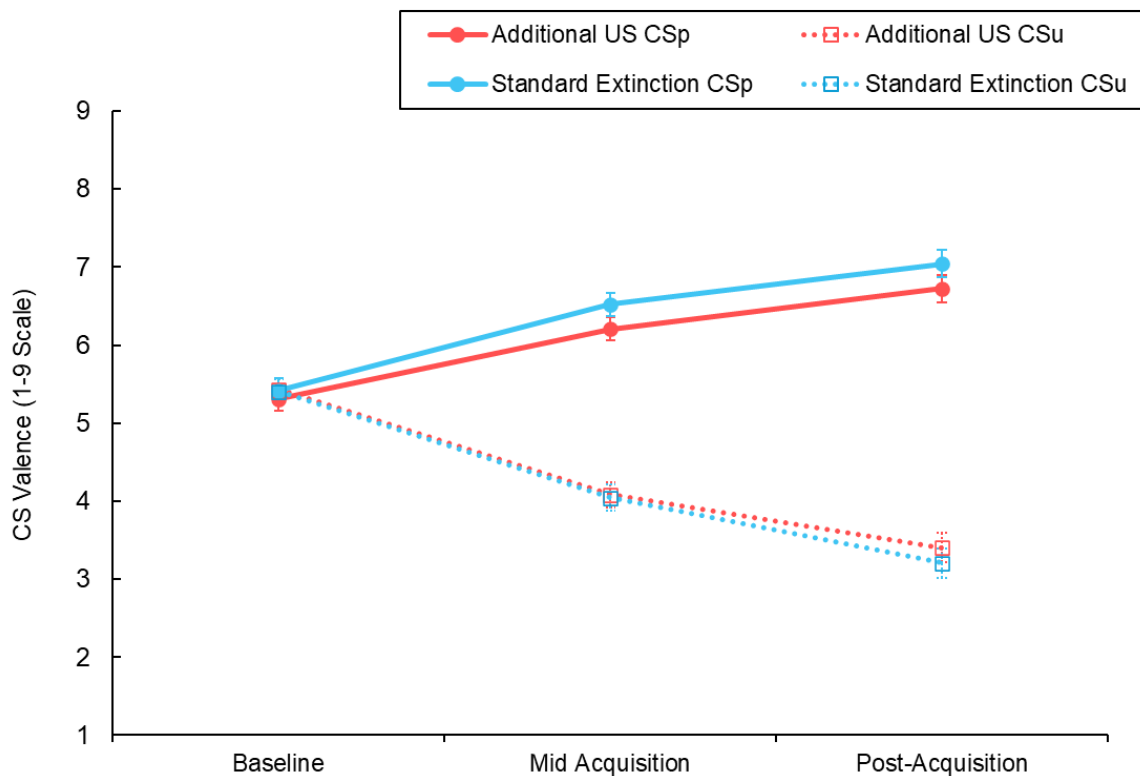
Note. CS valence ratings at baseline, mid-acquisition and post-acquisition. The standard error of mean is presented through the error bars.

US Expectancy

US expectancy ratings for the additional US group and standard extinction group are presented in Figure 8. A main effect of CS, $F(1, 139) = 873.55$, $p < .001$, $\eta p^2 = .863$, was moderated by a CS × Rating Time interaction, $F(1, 139) = 15.05$, $p < .001$, $\eta p^2 = .098$. Follow up analyses of the CS × Rating Time interaction time revealed that expectancy scores were higher for the CSp than the CSu at mid-acquisition, $F(1, 139) = 398.24$, $p < .001$, $\eta p^2 = .741$, and post-acquisition, $F(1, 139) = 945.59$, $p < .001$, $\eta p^2 = .872$. Conditional expectancy increased from mid-acquisition to post-acquisition, $p < .001$. The remaining omnibus effects were non-significant, $F \leq 2.07$, $p \geq .152$, $\eta p^2 \leq .015$.

Figure 8

US Expectancy During Acquisition

Note. US expectancy ratings at mid-acquisition and post-acquisition. The standard error of mean is presented through the error bars. Ratings above four shows that participants expected a pleasant picture and ratings less than four indicates that participants expected an unpleasant picture.
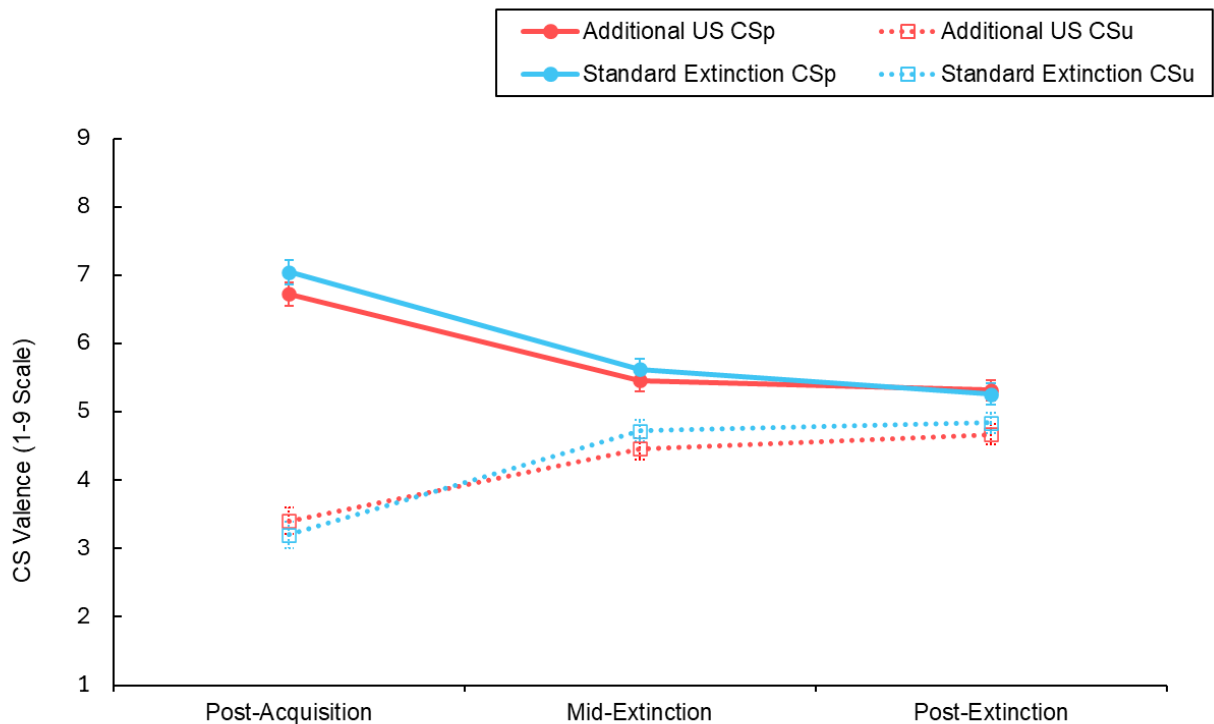
Extinction

CS Valence

CS valence ratings for the additional US group and standard extinction group are presented in Figure 9. A main effect of CS, $F(1, 139) = 127.37$, $p < .001$, $\eta p^2 = .478$, was moderated by a CS × Rating Time interaction, $F(2, 138) = 67.65$, $p < .001$, $\eta p^2 = .495$. Follow up analyses of the CS × Rating Time interaction revealed at post-acquisition, $F(1, 139) = 210.48$, $p < .001$, $\eta p^2 = .602$, mid-extinction, $F(1, 139) = 27.66$, $p < .001$, $\eta p^2 = .166$, and post-extinction, $F(1, 139) = 10.05$, $p = .002$, $\eta p^2 = .067$, the CSp was rated more pleasant than the CSu. Conditional valence decreased from post-acquisition to mid-extinction, $p < .001$, and decreased further from mid-extinction to post-extinction, $p = .020$. The remaining omnibus effects were non-significant, $F \leq 2.17$, $p \geq .118$, $\eta p^2 \leq .031$.

Figure 9

CS Valence During Extinction

Note. CS valence ratings at post-acquisition, mid-extinction and post-extinction. The standard error of mean is presented through the error bars.
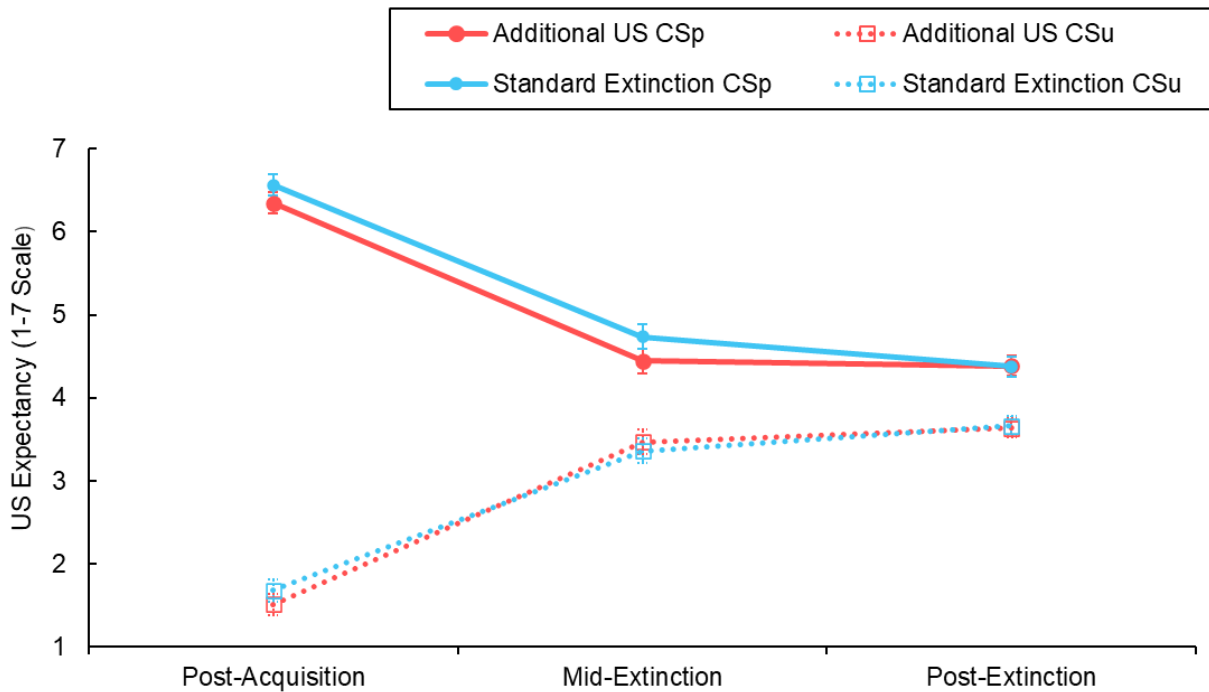
US Expectancy

US expectancy ratings for the additional US group and standard extinction group are presented in Figure 10. A main effect of CS, $F(1, 139) = 390.33$, $p < .001$, $\eta p^2 = .737$, was moderated by a CS × Rating Time interaction, $F(2, 138) = 162.87$, $p < .001$, $\eta p^2 = .702$. Follow up analyses of the CS × Rating Time interaction showed at post-acquisition, $F(1,139) = 945.59$, $p < .001$, $\eta p^2 = .872$, mid-extinction, $F(1,139) = 35.74$, $p < .001$, $\eta p^2 = .205$, and post-extinction, $F(1, 139) = 22.71$, $p < .001$, $\eta p^2 = .140$, the CSp had higher expectancy scores than the CSu. Conditional expectancy decreased from post-acquisition to mid-extinction, $p < .001$, and decreased from mid-extinction to post-extinction, $p = .014$. The remaining omnibus effects were non-significant, $F \leq 1.82$, $p \geq .166$, $\eta p^2 \leq .026$.

Figure 10

US Expectancy During Extinction

Note. US expectancy ratings at post-acquisition, mid-extinction and post-extinction. The standard error of mean is presented through the error bars. Ratings above four shows that participants expected a pleasant picture and ratings less than four indicates that participants expected an unpleasant picture.

Renewal

CS Valence

CS valence ratings for the additional US group and standard extinction group are presented in Figure 11. A main effect of CS, $F(1, 139) = 18.27$, $p < .001$, $\eta p^2 = .116$, was moderated by a CS × Rating Time interaction, $F(1, 139) = 11.30$, $p = .001$, $\eta p^2 = .075$. Follow up analyses of the CS × Rating Time interaction at post-extinction, $F(1, 139) = 10.05$, $p = .002$, $\eta p^2 = .067$, and renewal, $F(1, 139) = 23.74$, $p < .001$, $\eta p^2 = .146$, showed that the CSp was rated more pleasant than the CSu. Conditional valence increased from post-extinction to renewal, $p = .001$, signifying that renewal did occur but there was no significant difference

between the groups. The remaining omnibus effects were non-significant, $F \leq 0.55$, $p \geq .460$, $\eta p^2 \leq .004$.

Figure 11

CS Valence During Renewal
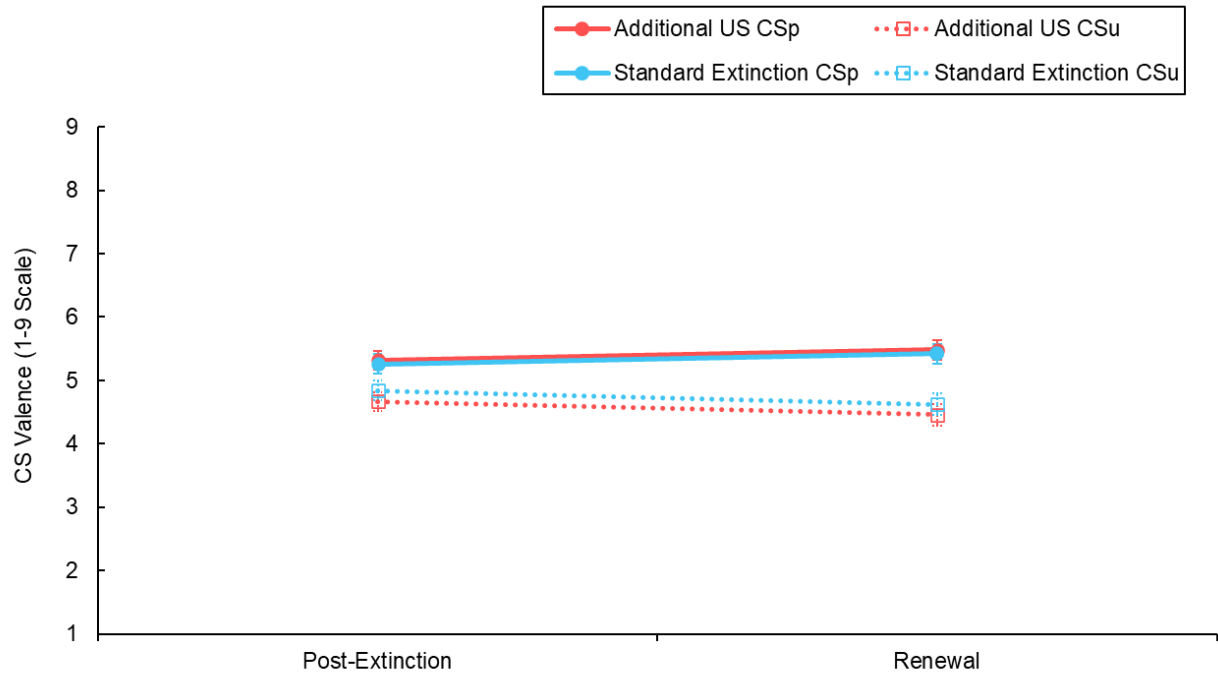
Note. CS valence ratings at post-extinction and renewal. The standard error of mean is presented through the error bars.

US Expectancy

US expectancy ratings for the additional US group and standard extinction group are presented in Figure 12. A main effect of CS, $F(1, 139) = 60.73$, $p < .001$, $\eta p^2 = .304$, was moderated by a CS × Rating Time interaction, $F(1, 139) = 23.64$, $p < .001$, $\eta p^2 = .145$. Follow up analyses of the CS × Rating Time interaction revealed that the CSp was evaluated as more pleasant at post-extinction, $F(1, 139) = 22.71$, $p < .001$, $\eta p^2 = .140$, and renewal, $F(1, 139) = 66.74$, $p < .001$, $\eta p^2 = .324$. Conditional expectancy increased from post-extinction to renewal, $p < .001$, indicating renewal was successful but there was no significant difference

between the groups. The remaining omnibus effects did not reach significance, $F \leq 0.48$, $p \geq$ .492, $\eta p^2 \leq .003$.

Figure 12

US Expectancy During Renewal

Note. US expectancy ratings at post-extinction and renewal. The standard error of mean is presented through the error bars. Ratings above four shows that participants expected a pleasant picture and ratings less than four indicates that participants expected an unpleasant picture.
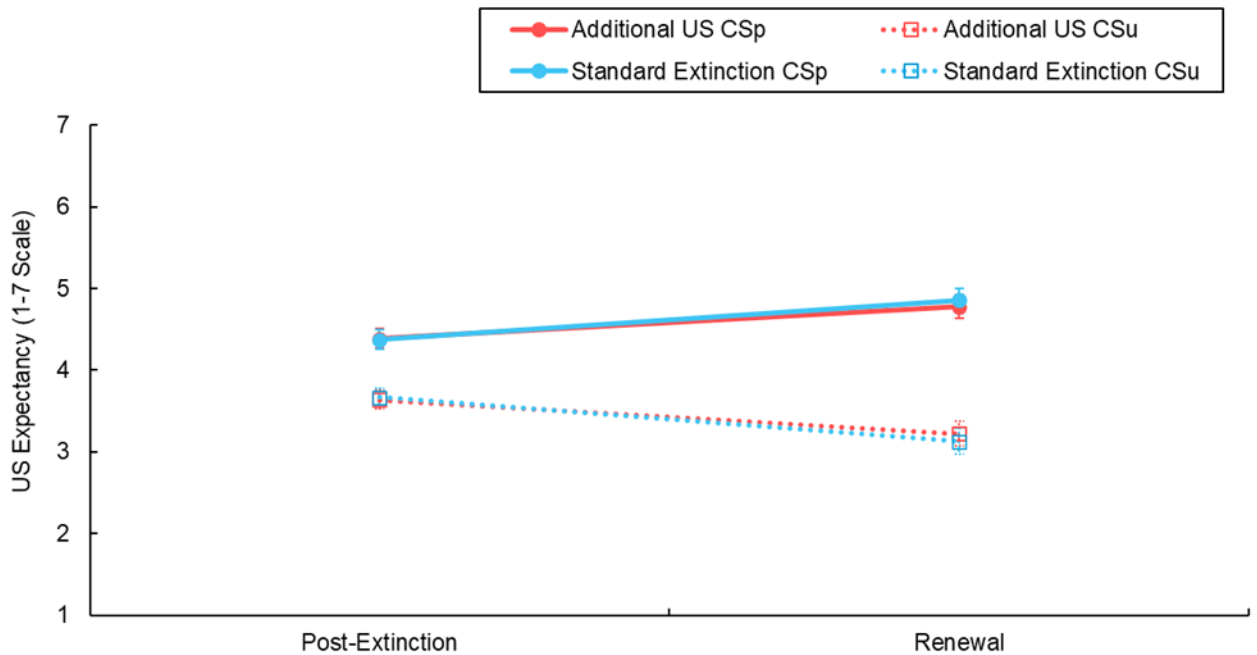
Discussion

In Experiment 2, we examined whether doubling the number of unpaired USs in extinction would decrease renewal of evaluative learning. We observed conditional valence and expectancy in acquisition for the additional US and standard extinction group. The learning acquired during acquisition diminished in extinction for both groups. Finally, there was an increase in conditional valence and expectancy during renewal, indicating that renewal did occur, but this was not moderated by group. These findings suggest that

increasing the number of unpaired USs in extinction does not reduce renewal in evaluative conditioning. This highlights that the ratio of unpaired USs to CS trials could not explain why we did not observe any influence of the unpaired USs in the additional US group during Experiment 1. It is possible that the positive and negative pictures used in the current study did not have the sufficient intensity to reduce renewal. As the general arousal account suggests that reducing renewal in fear conditioning may be mediated by increased arousal during extinction (Lipp et al., 2024; Waters et al., 2018; Waters et al., 2021), it is possible that we need to include USs that are higher in arousal as the results from fear conditioning have shown to reduce conditional responding returning with higher arousal stimuli such as using an electric shock or loud aversive sounds (Lipp et al., 2021; Thompson et al., 2018).

We carried out a third experiment to assess whether using higher intensity USs in extinction would reduce the renewal of evaluative learning. In the third experiment, we replaced positive and negative pictures with a melody sound as the pleasant US and an aversive human scream sound as the unpleasant US in acquisition and extinction. We used sounds for the USs as they have been used previously in evaluative conditioning (Green et al., 2020). The number of unpaired USs for the additional group was kept the same as in Experiment 2 (i.e., 12 melody sounds and 12 scream sounds) because we wanted to keep the ratio of unpaired USs to CS trials similar to fear conditioning studies. We hypothesised that conditional valence, and conditional expectancy would be present in acquisition. In extinction, we expected conditional valence and conditional expectancy to decrease. Lastly, we hypothesised that the re-emergence of conditional valence and expectancy in renewal would be smaller in the additional US group compared to the standard extinction group (i.e., less renewal in the additional US group).

Experiment 3

Methods

Participants

One hundred and forty participants (50 male; 90 female) between the ages of 18 and 61 ($M = 23.02$, $SD = 7.98$) voluntarily participated in the experiment. Participants were recruited from the psychology undergraduate course at Curtin University (students received course credit) or were via the researchers' network (general volunteers received no compensation). There were no participants excluded from the study. The power analysis was

the same as the previous experiments, but we recruited additional participants to replace those who failed the screen colour manipulation check and US valence assessment (if participants rated the melody as unpleasant or the scream as pleasant). This study was approved by the Curtin University Human Research Ethics Committee. Participants were randomly allocated to the additional US ($n = 72$) or the standard extinction group ($n = 68$).

Apparatus and Measures

USs were a pleasant melody sound (positive US; did not exceed 60 dBA) and an unpleasant human scream sound (negative US; did not exceed 80 dBA; taken from Moran & Bar-Anan, 2013). Participants heard the sounds through a set of headphones (Corsair HS55 Stereo Headset). The US expectancy scale was adjusted to include sounds instead of pictures (1 = always unpleasant, 4 = no sounds, 7 = always pleasant). The post-experimental questionnaire was adapted to have participants identifying which shape was paired with the scream, and which shape was paired with the melody. The US valence assessment (how pleasant/unpleasant did you find the scream sound or the melody sound) was included in the post-experimental questionnaire. The rest of the apparatus and measures was the same as in Experiment 1.

Procedure

Participants listened to the melody and scream sound through the headphones before they consented to the experiment. During acquisition, the CSp was paired with the melody and the CSu was paired with the human scream. For the US expectancy task, participants were asked to predict what kind of sounds will follow the shapes. In extinction, the standard extinction group received no USs, whereas the additional US group had 24 unpaired USs (12 melody and 12 human scream) presented during the middle of the intertrial interval. After the experiment, participants circled the shape that was paired with the scream and the melody sound during the beginning of the experiment. Lastly, participants would evaluate the scream and melody as unpleasant or pleasant. The rest of the procedure was the same as in Experiment 2.

Data Preparation and Analyses

The data preparation and analyses were the same as in Experiment 1.

Results

Preliminary Checks

An independent *t*-test confirmed that the additional US (*M* = 23.83, *SD* = 8.48) and the standard extinction group (*M* = 22.16, *SD* = 7.38) did not differ in age, *t*(138) = 1.24, *p* = .217. The pass to fail ratio for the manipulation check (screen colour) did not differ between the additional US (68:4) and standard extinction group (66:2), X^2(1, *N* = 140) = 0.58, *p* = .445. The contingency pass to fail ratio did not differ between the additional US group (70: 2) and the standard extinction group (63:5), X^2(1, *N* = 140) = 1.54, *p* = .214. The male to female gender ratio did not differ the additional US (30:42) and standard extinction group (20: 48), X^2(1, *N* = 140) = 2.29, *p* = .130. When comparing the US valence between the groups, a main effect was detected for US type, *F*(1, 138) = 878.30, *p* < .001, ηp^2 = .864, which revealed that the melody (*M* = 7.40, *SD* = 1.24) was rated as more pleasant than the scream sound (*M* = 2.61, *SD* = 1.21). The main effect of group, *F*(1, 138) = 0.19, *p* = .660, ηp^2 = .001, and the US Valence × Group interaction were non-significant, *F*(1, 138) = 0.15, *p* = .695, ηp^2 = .001, indicating that the ratings of the melody (additional US: *M* = 7.40, *SD* = 1.37; standard extinction: *M* = 7.40, *SD* = 1.10) and scream (additional US: *M* = 2.56, *SD* = 1.36; standard extinction; *M* = 2.68, *SD* = 1.03) did not differ between groups.
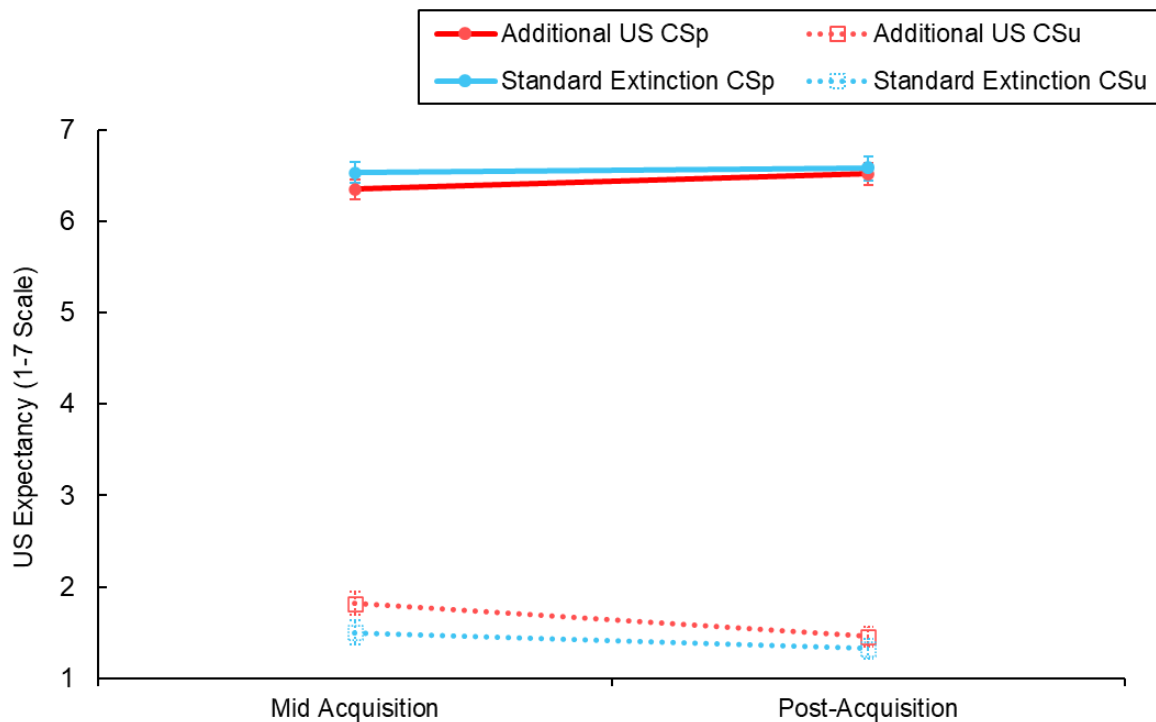
Acquisition

CS Valence

CS valence ratings for the additional US and standard extinction group are shown in Figure 13. Main effects for CS, *F*(1, 138) = 265.13, *p* < .001, ηp^2 = .658, and rating time, *F*(2, 137) = 18.69, *p* < .001, ηp^2 = .214, were moderated by a CS × Rating Time interaction, *F*(2, 137) = 155.15, *p* < .001, ηp^2 = .694. Follow up analyses of the CS × Rating Time interaction revealed that there were no differences between the CSp and CSu at baseline, *F*(1, 138) = 1.18, *p* = .279, ηp^2 = .008, but at mid-acquisition, F(1, 138) = 230.11, *p* < .001, ηp^2 = .625, and post-acquisition, *F*(1, 138) = 309.69, *p* < .001, ηp^2 = .692, evaluations of CSp were more pleasant than CSu. Conditional valence increased from baseline to mid-acquisition, *p* < .001, and increased from mid-acquisition to post-acquisition, *p* < .001. The remaining omnibus effect were *F* ≤ 1.34, *p* ≥ .264, ηp^2 ≤ .019.

Figure 13

CS Valence During Acquisition
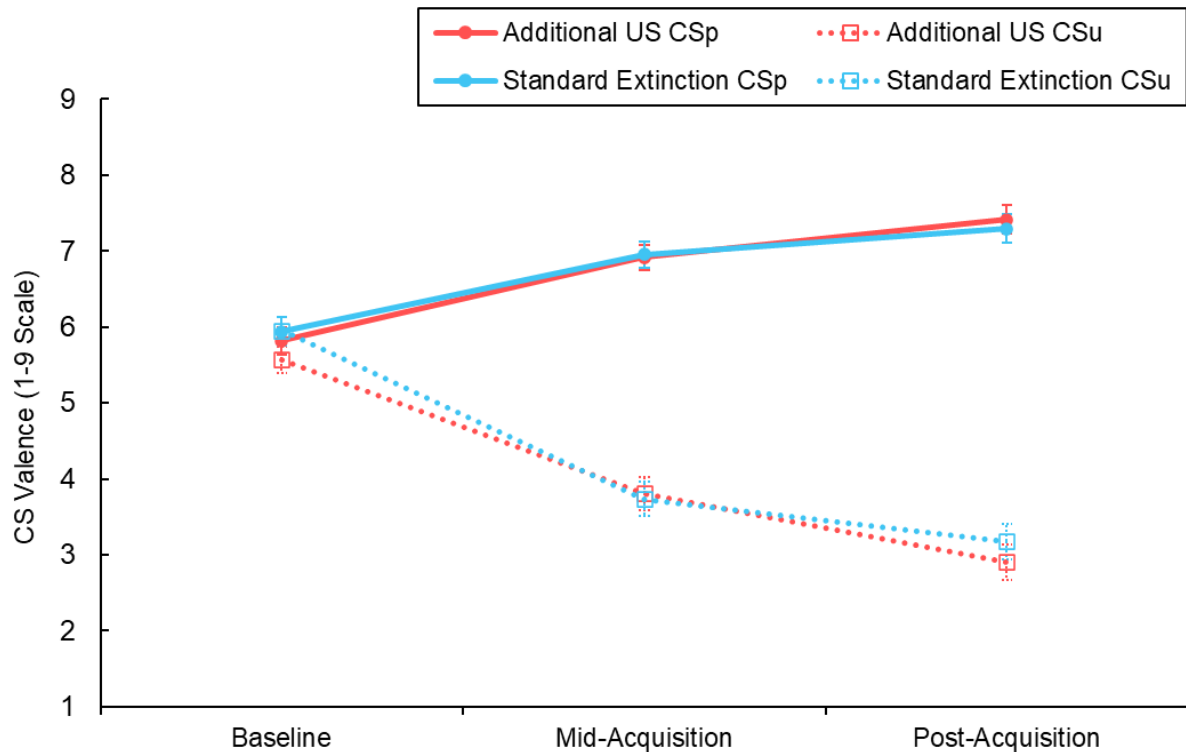
Note. CS valence ratings at baseline, mid-acquisition and post-acquisition. The standard error of mean is presented through the error bars.

US Expectancy

US expectancy ratings for the additional US and standard extinction group are shown in Figure 14. A main effect of CS, $F(1, 138) = 1438.96$, $p < .001$, $\eta p^2 = .912$, was moderated by a CS × Rating Time interaction, $F(1, 138) = 7.16$, $p = .008$, $\eta p^2 = .049$. Follow up analyses of the CS × Rating Time interaction indicated that the CSp was rated more pleasant than the CSu at mid-acquisition, $F(1, 138) = 971.20$, $p < .001$, $\eta p^2 = .876$, and post-acquisition, $F(1, 138) = 1292.59$, $p < .001$, $\eta p^2 = .904$. Conditional expectancy increased from mid-acquisition to post-acquisition, $p = .008$. The remaining omnibus effects were non-significant, $F \leq 3.55$, $p \geq .062$, $\eta p^2 \leq .025$.

Figure 14

US Expectancy During Acquisition

Note. US expectancy ratings at mid-acquisition and post-acquisition. The standard error of mean is presented through the error bars. Ratings above four shows that participants expected a pleasant picture and ratings less than four indicates that participants expected an unpleasant picture.
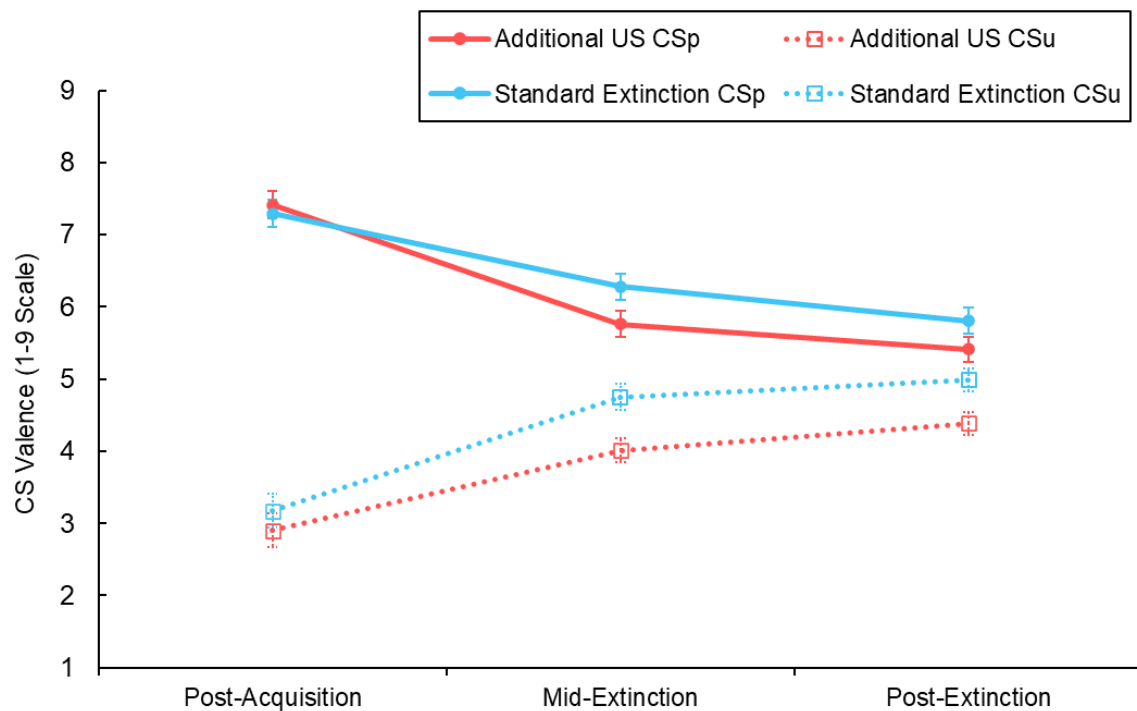
Extinction

CS Valence

CS valence ratings for the additional US and standard extinction group are shown in Figure 15. A main effect of CS, $F(1, 138) = 238.17$, $p < .001$, $\eta p^2 = .633$, group, $F(1, 138) = 7.27$, $p = .008$, $\eta p^2 = .050$, a Rating Time × Group interaction, $F(2, 137) = 5.97$, $p = .003$, $\eta p^2 = .080$, and a CS × Rating Time interactions, $F(2, 137) = 89.16$, $p < .001$, $\eta p^2 = .566$, were detected. Follow up analyses of the Rating Time × Group interaction revealed that at post-acquisition, $F(1, 138) = 0.20$, $p = .653$, $\eta p^2 = .001$, there were no differences between the groups. At mid-extinction, $F(1, 138) = 12.68$, $p < .001$, $\eta p^2 = .084$, and post-extinction, $F(1, 138) = 7.16$, $p = .008$, $\eta p^2 = .049$, the additional US group rated the CSs (overall ratings) as

less pleasant than the standard extinction group. Follow up analyses of the CS × Rating Time interaction showed that the CSp was rated as more pleasant than the CSu at post-acquisition, $F(1, 138) = 309.69$, $p < .001$, $\eta p^2 = .692$, mid-extinction, $F(1, 138) = 84.75$, $p < .001$, $\eta p^2 = .380$, and post-extinction, , $F(1, 138) = 37.78$, $p < .001$, $\eta p^2 = 215$. Conditional valence decreased from post-acquisition to mid-extinction, $p < .001$ and from mid-extinction to post-extinction, $p < .001$. The remaining omnibus effects were $F \leq 0.85$, $p \geq .359$, $\eta p^2 \leq .006$.

Figure 15

CS Valence During Extinction

Note. CS valence ratings at post-acquisition, mid-extinction and post-extinction. The standard error of mean is presented through the error bars.
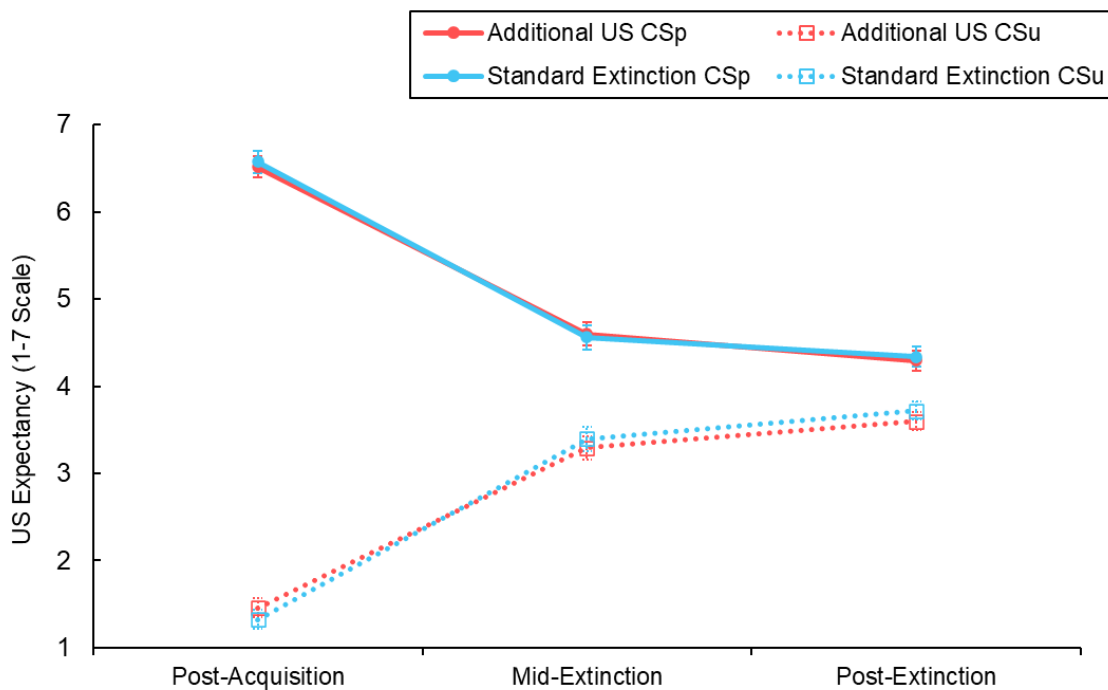
US Expectancy

US expectancy ratings for the additional US and standard extinction group are shown in Figure 16. A main effect of CS, $F(1, 138) = 529.63$, $p < .001$, $\eta p^2 = .793$, was moderated by a CS × Rating Time interaction, $F(2, 137) = 277.83$, $p = < .001$, $\eta p^2 = .802$. Follow up analyses of the CS × Rating Time interaction revealed that the CSp was evaluated as more

pleasant than the CSu at post-acquisition, $F(1, 138) = 1292.59$, $p < .001$, $\eta p^2 = .904$, mid-extinction, $F(1, 138) = 50.44$, $p < .001$, $\eta p^2 = .268$, and post-extinction, $F(1, 138) = 24.06$, $p < .001$, $\eta p^2 = .148$. Conditional expectancy decreased from post-acquisition to mid-extinction, $p < .001$, and from mid-extinction to post-extinction, $p < .001$. The remaining omnibus effects were non-significant, $F \leq 0.85$, $p \geq .432$, $\eta p^2 \leq .012$.

Figure 16

US Expectancy During Extinction

Note. US expectancy ratings at post-acquisition, mid-extinction and post-extinction. The standard error of mean is presented through the error bars. Ratings above four shows that participants expected a pleasant picture and ratings less than four indicates that participants expected an unpleasant picture.
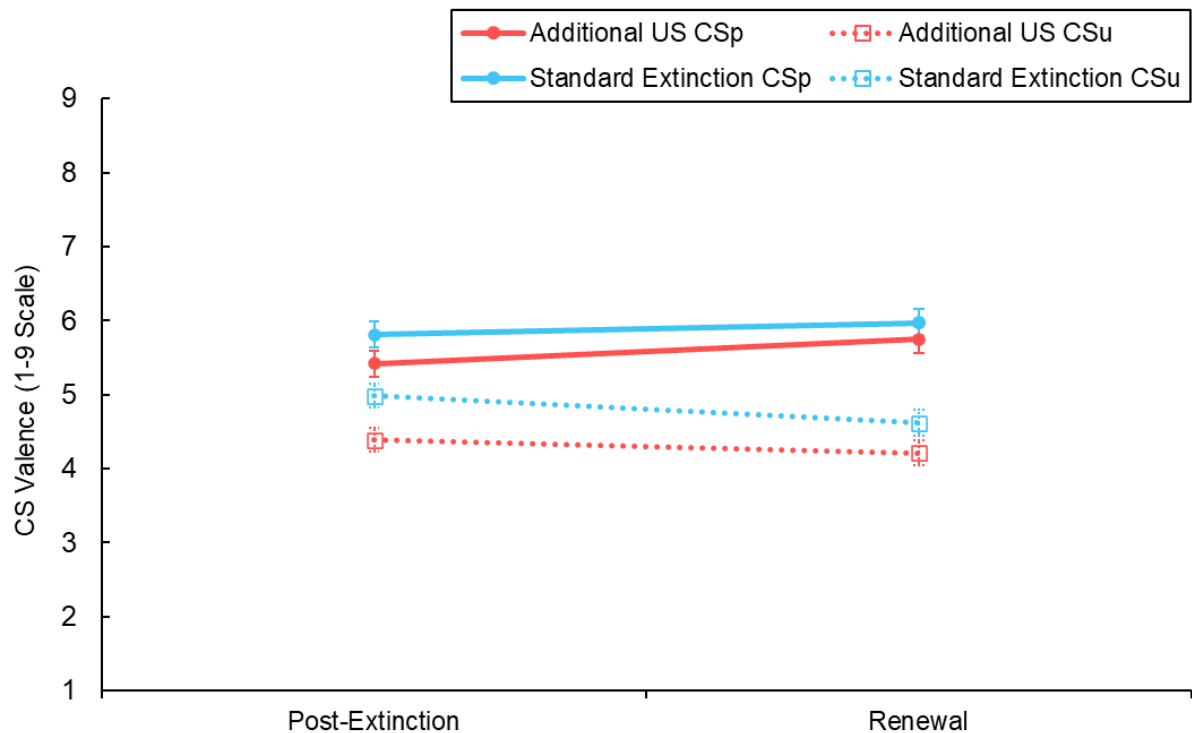
Renewal

CS Valence

CS valence ratings for the additional US and standard extinction group are shown in Figure 17. Main effects of CS, $F(1, 138) = 62.35$, $p < .001$, $\eta p^2 = .311$, group, $F(1, 138) = 6.29$, $p = .013$, $\eta p^2 = .044$, which shows that overall ratings for the CSs are more pleasant in

the standard extinction group compared to additional US group, and a CS × Rating Time interaction, $F(1, 138) = 9.47$, $p = .003$, $\eta p^2 = .064$, were detected. Follow up analyses of the CS × Rating Time interaction revealed that the CSp was rated as more pleasant than the CSu at post-extinction, $F(1, 138) = 37.78$, $p < .001$, $\eta p^2 = .215$, and renewal, $F(1, 138) = 56.84$, $p < .001$, $\eta p^2 = .292$. Conditional valence increased from post-extinction to renewal, $p = .003$, but there were no significant differences between the groups. The remaining omnibus effects were $F \leq 1.89$, $p \geq .171$, $\eta p^2 \leq .014$.

Figure 17

CS Valence During Renewal

Note. CS ratings at post-extinction and renewal. The standard error of mean is presented through the error bars.
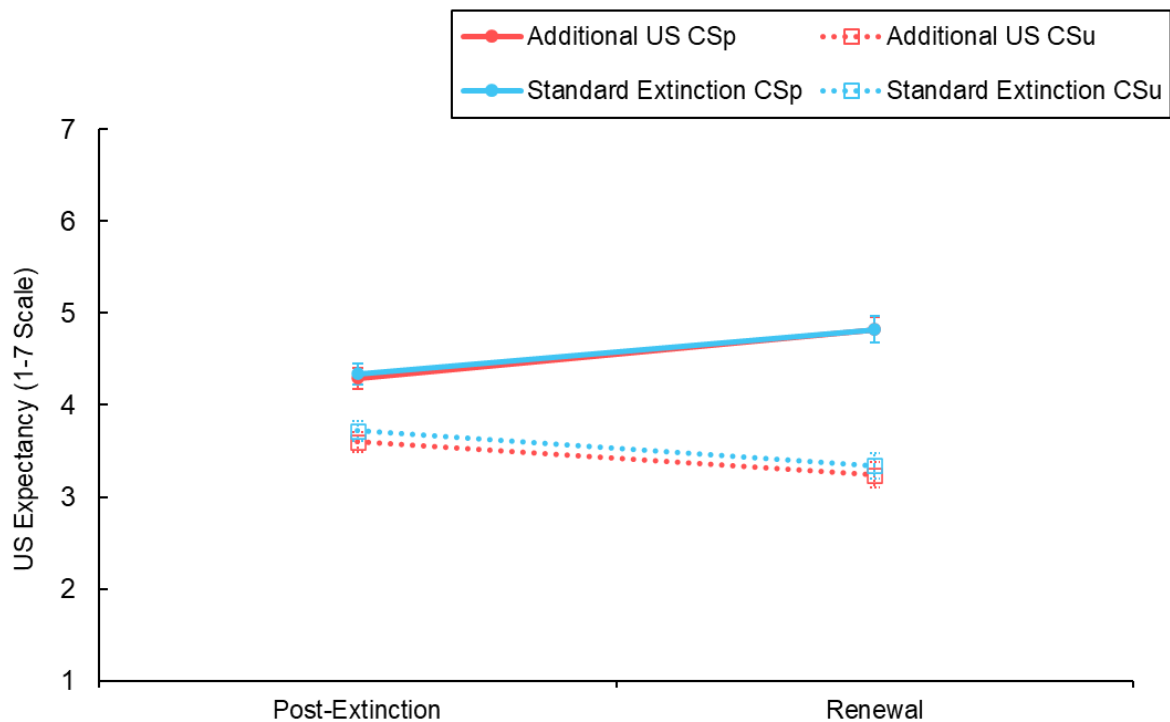
US Expectancy

US expectancy ratings for the additional US and standard extinction group are shown in Figure 18. A main effect of CS, $F(1, 138) = 72.43$, $p < .001$, $\eta p^2 = .344$, was moderated by

a CS × Rating Time interaction, $F(1, 138) = 23.68$, $p < .001$, $\eta p^2 = .146$. Follow up analyses of the CS × Rating Time interaction indicated that the CSp had higher expectancy scores than the CSu at post-extinction, $F(1, 138) = 24.06$, $p < .001$, $\eta p^2 = .148$, and renewal, $F(1, 138) = 74.69$, $p < .001$, $\eta p^2 = .351$. Conditional expectancy increased from post-extinction to renewal, $p < .001$, but there were no significant differences between the groups. The remaining omnibus effects are $F \leq 3.57$, $p \geq .061$, $\eta p^2 \leq .025$.

Figure 18

US Expectancy During Renewal

Note. US expectancy ratings at post-extinction and renewal. The standard error of mean is presented through the error bars. Ratings above four shows that participants expected a pleasant picture and ratings less than four indicates that participants expected an unpleasant picture.

Discussion

In Experiment 3, we examined whether using more intense USs would reduce renewal in evaluative conditioning. We observed conditional valence and expectancy during acquisition in the additional US group and standard extinction group. Conditional valence and expectancy significantly reduced during extinction, but unexpectedly, we found that the participants in the additional US group rated the CSs as less pleasant compared to the standard extinction group. This could be due to the human scream sound being more aversive than the melody sound in the additional US group which may have negatively influenced the participants' mood, and thus, affected their CS valence ratings. Prior research suggests that negative affect may decrease the valence of the CS (Zbozinek & Craske, 2017). Lastly, conditional valence and expectancy remerged in renewal, but this was not moderated by group.

General Discussion

The current study examined whether presenting unpaired USs during extinction would reduce renewal of evaluative conditioning. In all experiments, participants went through three phases which consisted of acquisition, extinction, and renewal. Renewal was tested with two screen colours (e.g., blue and grey) with acquisition occurring on one screen colour (e.g., blue), extinction changed to a different screen colour (e.g., grey) and renewal took place on the original screen colour (e.g., blue). In Experiment 1, we presented six positive and six negative unpaired USs during extinction in the additional US group and the standard extinction group included no USs. In Experiment 2, we doubled the number of unpaired USs (24 unpaired USs; 12 positive and 12 negative) presented in extinction for the additional US group. In Experiment 3, we used sounds as the USs (a melody and a human scream) and presented 24 unpaired USs (12 melody and 12 human scream) across extinction for the additional US group.

Across all the experiments, we found that conditional valence increased from baseline to post-acquisition and conditional expectancy increased from mid-acquisition to post-acquisition. Conditional valence and conditional expectancy were significantly reduced from post-acquisition to post-extinction, which was consistent with Luck and Lipp (2020b). We observed an increase of conditional valence and expectancy in all experiments from post-extinction to renewal, replicating findings from Luck and Lipp (2020b) and extending these findings by demonstrating for the first time that renewal can occur using sounds as the USs.

Nevertheless, we did not find any significant differences between the additional US group and the standard extinction group after renewal and hence, these findings suggest that unpaired USs did not affect extinction in evaluative conditioning. Our results were inconsistent with Lipp et al. (2021), and Lipp et al. (2024) who have both found significant differences in the renewal of fear conditioning between groups as the unpaired US group had reduced electrodermal responding compared to the standard extinction group during renewal.

This could suggest that there are distinctions between how unpaired USs respond in evaluative conditioning compared to fear conditioning as renewal has shown to decrease in fear conditioning, but within our procedural parameters, we were not able to replicate these results in evaluative conditioning. Firstly, the inconsistent effects of the unpaired USs may point towards differences in the underlying mechanisms in evaluative and fear conditioning. Prior research has shown that spontaneous recovery is evident in fear conditioning but not in evaluative conditioning (Luck & Lipp, 2020b; Thompson et al., 2018). Additionally, we have also used different measures in assessing renewal compared to previous fear research. Our study only comprised of self-rating measures which were CS valence and US expectancy, and we found no significant differences between the groups in both measures, however, Lipp et al. (2021) found the unpaired group to show less renewal through skin conductance responses but not in self-report measures. Although, Vervliet et al. (2010) did include US expectancy as a measure when assessing the effects of unpaired USs on contextual renewal, planned comparisons showed a significant difference between the CS+ and CS- in the standard extinction group and not in the unpaired group after the first trial in renewal (i.e., renewal was reduced in the unpaired group), but overall, did not find a group interaction. We do not suggest that using self-report measures shows that evaluative conditioning is distinctly different from fear conditioning, but future research will need to investigate whether US expectancy can demonstrate that renewal of fear can be reduced in fear conditioning. This will be important as it may provide further evidence on whether there are differences between the underlying processes in fear and evaluative conditioning. Two other alternative explanations for our unexpected findings are the differences between the design of evaluative conditioning compared to fear conditioning and the difference in intensity of the USs.

In the current study design, we included a CSp (i.e., positive valence) and a CSu (i.e., negative valence) whereas, in a fear conditioning paradigm, there is a CS+ (i.e., negative valence) and a CS- presented alone during all stages of the experiment (Lipp et al., 2021). For the additional US group to show less renewal than the standard extinction group in evaluative

conditioning, both the acquired positive and negative valence have to be reduced, however with fear conditioning, research has only shown to reduce negative valence after renewal (i.e., fear; Lipp et al., 2021) or with appetitive conditioning, decreased positive valence after reacquisition (i.e., chocolate mousse; van den Akker et al., 2015). The pattern of results from our study may indicate that unpaired USs do not simultaneously reduce both positive and negative valence during renewal and therefore, the effects of the unpaired USs could likely be stronger when the positive valence is separated from the negative valence. This could also potentially result in stronger context conditioning for the unpaired USs (i.e., when the context in extinction becomes the best predictor for the US) and enhance extinction learning to the CS (Rescorla & Wagner, 1972; Lipp et al., 2024). It is possible that a change in design is needed for renewal to be reduced. Renewal of evaluating learning has been previously demonstrated in separate positive and negative conditioning designs (Luck & Lipp, 2020b). For instance, the positive conditioning experiment consisted of a CSp and a CSn (neutral pictures presented alone in all stages) and the negative conditioning experiment included a CSu and CSn as well. Future investigations in evaluative conditioning will need to test whether unpaired USs can influence the additional US group during renewal in separate positive and negative conditioning designs.

The general arousal account was tested in Experiment 3 by increasing the intensity of the USs from positive and negative pictures to a pleasant melody and an unpleasant sound as there needs to be a certain level of arousal during extinction for renewal to be decreased (Lipp et al., 2024; Waters et al., 2018; Waters et al., 2021). However, the unpaired sounds did not affect the additional US group during renewal. It is possible that the melody sound and human scream sound did not have an adequate level of arousal to enhance extinction learning, since the human scream sound used in our experiment may have been less aversive than previous USs employed in fear conditioning. Although aversive sounds have been used previously to demonstrate the renewal of fear, there may be a difference in arousal between a human scream sound used in our experiment and the sound of a metal fork scraping on a slate which was used in Lipp et al. (2021) study. Future research can investigate whether using USs that are more arousing than a melody and a human scream sound and whether a certain level of arousal is needed during extinction for the unpaired USs to affect the additional US group in evaluative conditioning. Another potential method that could test the general arousal account in evaluative conditioning is using a negative conditioning design with two different USs. For instance, during acquisition, the CSu would be paired with negative pictures and the

CSn would be presented alone, but in extinction, the CSu would have unpaired presentations of an electric shock instead of negative pictures. The electric shocks included during extinction could determine if it is a higher arousing stimulus that is required for renewal to be reduced.

We are aware that our current experiment may be subject to demand characteristics as we only used explicit measures (Mitchell et al., 2003). Since the current experiment involves self-reported measures, the responses are under the participants' control which means they can be manipulated to meet our expectations of the study. We believe that it is possible that the demand characteristics could explain the results of acquisition, extinction, and renewal but not the differences between the standard extinction and additional US group. Demand characteristics could have also increased using repeated measures in the current experiment. Implicit measures such as affective priming (i.e., the CS is presented as a prime followed by a positive or negative target word which the participant needs to categorise and assesses the speed of their response to how pleasant or unpleasant a picture is) are less affected by demand characteristics and have been used previously in evaluative conditioning (Gawronski & De Houwer, 2014; Luck & Lipp, 2020a). However, using affective priming to measure renewal is difficult because renewal can only be seen in the first few trials after extinction, and since affective priming uses CSs as primes (presented 40-80 times), the return of conditional valence may not be observed as there would be more trials needed during renewal compared to explicit measures (Luck and Lipp, 2020b). Alternatively, an implicit measure that could be used in future research for renewal is the blink startle, which is a brain-stem reflex that is not consciously controlled by the individual (Lipp, 2006; Luck & Lipp, 2020b). However, higher intensity USs such as sounds will need to be used for the blink startle to be measured (Lipp, 2006; Luck & Lipp, 2020b). It will be difficult to implement in evaluative conditioning as the probes used in the blink startle are aversive, and it is unclear whether this impacts how valence is measured (Lipp, 2006; Luck & Lipp, 2020b).

In conclusion, the pattern of results demonstrates that presenting unpaired presentations of the US does not reduce renewal of evaluative conditioning. We were able to replicate renewal of evaluative conditioning and extend these findings by using sounds to demonstrate renewal for the first time. This has important implications for the developing interventions in the future that focus on removing negative attitudes towards social groups as the results from our study may indicate that using unpaired USs is not a suitable technique in reducing the return of negative attitudes. Future avenues of research could use other

approaches from fear conditioning that have diminished the return of conditional responding such as gradual extinction and whether this can be replicated in evaluative conditioning (see Gershman et al., 2013). Taken together, we believe that using pictures and sounds as unpaired USs may not be an effective method in reducing renewal in evaluative conditioning, but more research will need to be conducted to assess if unpaired USs can operate in evaluative conditioning and whether there are differences between the underlying processes in evaluative and fear conditioning.

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