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The relative effectiveness of extinction and counter-conditioning in diminishing children's fear

Carol Newall [a, *], Tiffany Watson [b], Kerry-Ann Grant [c], Rick Richardson [d]

[a] Department of Educational Studies, Macquarie University, Australia
[b] Department of Psychology, Macquarie University, Australia
[c] Centre for Emotional Health, Macquarie University, Australia
[d] School of Psychology, University of New South Wales, Australia

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ABSTRACT

Two behavioural strategies for reducing learned fear are extinction and counter-conditioning, and in this study we compared the relative effectiveness of the two procedures at diminishing fear in children. Seventy-three children aged 7–12 years old ($M = 9.30$, SD = 1.62) were exposed to pictures of two novel animals on a computer screen during the fear acquisition phase. One of these animals was paired with a picture of a scared human face (CS+) while the other was not (CS-). The children were then randomly assigned to one of three conditions: counter-conditioning (animal paired with a happy face), extinction (animal without scared face), or control (no fear reduction procedure). Changes in fear beliefs and behavioural avoidance of the animal were measured. Counter-conditioning was more effective at reducing fear to the CS + than extinction. The findings are discussed in terms of implications for behavioural treatments of childhood anxiety disorders.

Anxiety disorders affect 15–20% of youth, making these disorders among the most prevalent psychiatric conditions in childhood and adolescence (Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012; Merikangas, Nakamura, & Resskerm, 2009). When left untreated, anxiety interferes with daily functioning, including academic achievement and social skills development (Ezpeleta, Keeler, Erkanli, Costello, & Angold, 2001). The origin of childhood anxiety disorders is a subject of considerable research interest because it informs both post-onset interventions as well as prevention strategies. While there is some debate about the relative contribution of various aetiological factors to childhood anxiety problems, learning experiences (e.g., adverse events, provision of negative information) are considered major contributors to fear and anxiety onset (Askew & Field, 2007; Hoven et al., 2005; Muris & Field, 2010; Rachman, 1977). However, much less is known about the role of children's learning experiences in fear reduction. Understanding how children reduce fear is important for at least two reasons. First, some have suggested that difficulties in reducing fear normally during childhood may be a marker of risk for anxiety disorders (Craske et al., 2008; Waters, Henry, & Neumann, 2009). Second, understanding the learning processes involved in reducing fear will contribute to the development of effective prevention and treatment strategies (McGuire et al., 2016).

Of the few studies that have examined fear reduction in children, the majority has examined a fear reduction technique called *extinction* (McGuire et al., 2016). In extinction, a conditioned stimulus (CS; e.g., a picture of a bell) that was previously paired repeatedly with a biologically significant and aversive unconditioned stimulus (US; loud ringing) is now presented alone, without the US (e.g., Michalska et al., 2016). The fear elicited by the CS is decreased over repeated non-reinforced presentations. The extinction procedure is the laboratory analogue of exposure therapy for anxiety disorders. In exposure therapy the client experiences, often in a graded fashion, the feared situation or cue. In this way, the client is 'exposed' to the feared CS or context without the anticipated negative outcome, just like extinction. There has been considerable research on extinction over the past decade, with the intent of eventually improving the treatment of adult anxiety disorders (Milad & Quirk, 2012; Quirk et al., 2010). Emerging research suggests that extinction is also an effective technique for reducing fear in children (Craske et al., 2008; Liberman, Lipp, Spence, &

* Corresponding author. Department of Educational Studies, Macquarie University, 2109, Australia.
E-mail address: carol.newall@mq.edu.au (C. Newall).

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March 2006; Neumann, Waters, & Westbury, 2008; Waters et al., 2009).

An alternative technique for reducing fear is counter-conditioning, which involves pairing the feared CS with an appetitive/positive outcome (e.g., food instead of a loud ringing). Over repeated CS-positive US pairings, the fear response declines, and is often replaced by an appetitive response (e.g., approach towards the CS; Dickinson & Pearce, 1977). There have been substantially fewer studies on counter-conditioning than extinction in both adults and children. However, the few studies that have examined counter-conditioning in adults indicate that it is not only effective but may even be a superior fear reduction technique compared to extinction (Kerkhof, Vansteenwegen, Baeyens, & Hermans, 2010; Raes & De Raedt, 2012) because it may enhance and deepen extinction by the surprising presentation of a positive outcome (Rescorla & Wagner, 1972). Another reason that counter-conditioning might be more effective than extinction is because it can reduce the new valence acquired by the CS during conditioning. That is, in addition to learning a CS-US association during acquisition, participants may also acquire a "liking" or "disliking" of the CS, a process referred to as "evaluative" learning (for review see De Houwer, Thomas, & Baeyens, 2001). In extinction the CS is merely presented repeatedly by itself, thereby breaking the associative link between the two but not necessarily altering the participants' liking/disliking of the CS. Indeed, evaluative learning is thought to be relatively robust against extinction (e.g., Díaz, Ruiz, & Bayens, 2005; Mason & Richardson, 2010; Vansteenwegen, Francken, Vervliet, De Clercq, & Eelen, 2006). In contrast, in counter-conditioning the CS is paired with an oppositely-valenced US (e.g., a CS previously paired with an aversive outcome is now paired with a positive outcome) which has been shown to alter evaluative learning (e.g., Baeyens, Eelen, Van den Bergh, & Crombez, 1989). There is emerging evidence in conditioned taste aversion (Kerkhof et al., 2010) and fear learning (Raes & De Raedt, 2012) supporting the suggestion that counter-conditioning may be superior to extinction in adult participants.

A recent finding suggests that counter-conditioning could also be more effective than extinction at reducing learned fear in children 7–12 years of age (Reynolds, Field, & Askew, 2017). Though presented as modelling or vicarious learning, the procedure used in that study has all the hallmarks of Pavlovian conditioning: a novel cue (i.e., CS, which was a picture of an unfamiliar animal presented on screen) is paired with a biologically significant outcome (US; a scared human face). The reason this procedure is often described as 'vicarious' is due to the nature of the US. Specifically, the child is being exposed to someone else expressing fear rather than being *directly* exposed to an aversive stimulus themselves. Vicarious learning has been posited to be a major pathway of anxiety development because children often report indirect experiences (i.e., vicarious observation, being told something is dangerous) as triggers of fear (Askew & Field, 2007; Muris & Field, 2010).

In Reynolds et al.'s (2016) study, counter-conditioning was shown to be a more effective fear reduction technique than extinction. In that study there were a number of indices of learned fear, including self-report, two behavioural avoidance tasks, heart rate, and attention bias. Counter-conditioning led to a reduction on two of these indices (heart rate and avoidance) while, surprisingly, extinction was ineffective at reducing fear on *all* measures. The finding that extinction was completely ineffective is inconsistent with other research in healthy youths who had acquired fear through Pavlovian conditioning (Michalska et al., 2016; Neumann et al., 2008) as well as major theoretical frameworks for fear reduction (e.g., Bouton, 2002; Rescorla & Wagner, 1972). It should also be noted that Reynolds et al. did not replicate a key previous finding from their laboratory – loss of fear on the fear beliefs self-report measure following counter-conditioning (Dunne & Askew, 2013). These inconsistent and surprising results warrant further investigation into the relative effectiveness of the two fear reduction techniques in children. In the present study, we used a design that was almost identical to that used by Reynolds et al. in order to compare extinction and counter-conditioning in reducing learned fear, as measured on self-report and avoidance, in children 7–12 years of age.[1] Based on emerging evidence in the adult and child literature, as well as the learning theories discussed above, counter-conditioning was expected to be superior to extinction in reducing children's fear learning in this study.

1. Methods

1.1. Participants

Of the 73 children (7–12 years of age) that completed the experiment seven were excluded for failing manipulation checks at the end of acquisition training (i.e., they showed no awareness of an association between the CS and the US), leaving 66 children (57.6% male). The majority of families were Caucasian Australian ($n = 53$) while other families self-identified as Asian ($n = 7$), Middle-Eastern ($n = 1$), or 'other' ($n = 5$). Subsequent statistical analyses excluded children that did not show learning on the two fear indices ($n = 12$; 18.2%. See below in *Results* for the exclusion process). The remaining children showed either learning on one ($n = 22$; 33.3%) or both indices ($n = 32$; 48.5%). It is worth noting that the majority of children showed some learning (cumulative percentage of 81.8%). The non-learners and learners did not differ on Age, ethnicity, anxiety severity (measured by the *Spence Anxiety Scale*, see below under *Measures*) or gender composition (p range: 0.17-0.84).

Families were recruited via flyers and advertisements placed in local newspapers, websites, and businesses. Written consent was obtained from each child as well as the child's parent. Each family received $50 for their participation in the study as reimbursement for time and travel cost. The study was approved by the Macquarie University Ethics Committee for Human Research (reference number 5201400139).

1.2. Measures

1.2.1. Spence children anxiety scale

The Spence Children Anxiety Scale (SCAS) is a 45-item self-report measure used to measure child anxiety (Spence, 1997). On the SCAS, children rate how often each statement happens to them on a 4-point Likert-scale, never (0) to always (3). An example question is, "I worry about things". Higher scores indicate higher levels of anxiety. The SCAS has previously been shown to have high internal reliability (Spence, 1997). In this study Cronbach's alpha was good ($\alpha = 0.89$).

1.2.2. Fear Belief Questionnaire

The Fear Belief Questionnaire (FBQ; Field & Lawson, 2003) was used to measure fear beliefs towards each animal picture at baseline, after acquisition, and after fear reduction. Additionally, the FBQ was used to assess fear beliefs towards animal pictures in a pilot study (described below). The FBQ consists of seven hypothetical situations, and responses are reported on a 5-point Likert-scale, ranging from 0 (*No, not at all*) to 4 (*Yes, definitely*). Items in the

[1] This study was in progress prior to the publication of Reynolds et al., and the current study was modelled on the counter-conditioning procedure used in Dunne and Askew (2013).

FBQ include *"would you be happy if you found a [linsang/ratel] in your garden?"* and *"would you be scared if you saw a [linsang/ratel]?"* The FBQ has been used extensively to assess fear learning of novel animals in past research with children (Dunne & Askew, 2013; Field & Lawson, 2003) with higher scores indicating higher fear beliefs. Cronbach's alpha for the current study was good, ranging from 0.75 to 0.88.

1.2.3. Nature Reserve Task

A variation of the Nature Reserve Task (NRT) was used to measure behavioural avoidance (Field & Storkson-Coulson, 2007). In this study the NRT consisted of a green rectangular board (60 cm × 30 cm) representing a nature reserve or bushland where the two stimulus animals (ratel and linsang) live. Photos of the animals were positioned at one end of the board. The side of presentation for each animal was counterbalanced across the study. Children were asked to imagine that the board is a bushland, a term familiar to Australian children. Children were then instructed to imagine that they were a Lego figurine visiting the bushland, and asked to place 'themselves' where they would most like to be while visiting the bushland. Distance between the LEGO avatar and the animal picture was used as the index of avoidance/approach behaviour, with greater distance indicating greater avoidance of that animal. The NRT has been previously used with children to measure avoidance style and how avoidance changes towards animals previously paired with a fear face (Dunne & Askew, 2013; Field & Storkson-Coulson, 2007).

1.3. Materials and equipment

1.3.1. Animal pictures

Two colour pictures (400 × 300 pixels) of novel animals from South America and Asia, the ratel and linsang, were used as conditioned stimuli (CS). The two animal pictures were selected based on the results of a pilot study. In the pilot study, 30 children, aged 7–12 years (20 female, $M = 9.90$ years, $SD = 1.92$), rated animal pictures online. Each child saw six pictures of unfamiliar animals and rated each using the Fear Belief Questionnaire (FBQ). The pictures of the ratel and linsang were found to have the most comparable FBQ responses (ratel: $M = 2.52$, $SD = 1.02$; linsang: $M = 2.36$, $SD = 1.26$; $t(24) = -1.67$, $p = 0.11$) and were therefore selected as the conditioned stimuli in this study.

1.3.2. Faces

Two adult male and two female face images (300 × 400 pixels; from the NimStim set of pictures, Tottenham et al., 2009), one of each expressing fear and the other expressing happiness, were used as unconditioned stimuli (US). The gender of the face was consistent with each participant's gender.

1.3.3. Apparatus

A 16-inch Toshiba laptop computer was used to present all picture stimuli. The screen resolution was 1280 × 1024 pixels. The screen layout was a white background. The software used was Tobii Suite, although no eyetracking data was recorded. For CS + trials, the two images (the animal CS and the face US) were separated by a 2:4 aspect ratio (i.e., a 200 × 400 pixel of white space). For CS- trials, the animal CS appeared in the same space as the animal in the CS + trials, but without the US.

1.4. Procedure

Demographic and SCAS questions were completed online by the parents and children in the week prior to the research session. The study was conducted with each child individually. Upon arrival, parents and children completed the consent forms. The children were then assessed on baseline measures of the FBQ and NRT for each animal, followed by the computerised acquisition phase and then the fear reduction phase. All phases were presented as a slide show via the computer screen. To increase motivation to look at the computer screen, each child was instructed that their task was to guess which animal was followed by something surprising. The *acquisition phase* included 20 animal-face pairings; one animal (CS+) was always paired with a scared face while the other animal (CS-) was always presented alone. Each animal was presented 10 times. The linsang and ratel pictures were counterbalanced for CS type across children. The animal-face pairings were presented for two seconds in total. The CS+ was presented alone for one second, and then with the face US on the opposite side of the screen (randomised) for the remaining one second. CS- trials consisted of the animal picture being presented for two seconds alone. Trial order was pseudo-randomised with the constraint that no more than three of a type (e.g., CS+) occurred in a row. A variable interval of two, three, or four seconds followed each trial. The total duration for the acquisition phase was two minutes. Following the acquisition phase, children completed the post-acquisition measures: the FBQ and NRT (each for the second time). Additionally, children were asked about what they saw on the computer and which animal was followed by "something surprising" to check whether children made the association between the CS+ and the US.

Prior to the *fear reduction phase*, participants were randomly assigned to one of three groups: Extinction, Counter-Conditioning (CC), or Control. In the Extinction Group, both animals (CS+ and CS-) were presented alone, without a face, a further 10 times (two second presentation each time). In the Counter-Conditioning Group, children saw both animals a further 10 times but the animal (CS+) that had previously been paired with a scared face was now paired with the same person displaying a happy facial expression. In this condition, the CS+ was presented alone for one second and then paired with the happy face US for a further one second. Presentations of the CS+ and CS- were pseudo-randomised with the constraint, as before, that no more than three of a type of CS (e.g., CS+) occurred in a row. The Control Group viewed 20 nonsense scrambled words instead of animal pictures for the same length of time. The duration of the fear-reduction phase was two minutes. All participants then completed the FBQ and NRT for the third and final time (*Test*). All children were debriefed in the company of their parent and given factual information about the animals.

1.5. Data transformation

For the FBQ, average scores were first calculated and then difference scores (i.e., the CS- score was subtracted from the CS + score) were taken as an index of discriminant fear learning. Positive scores indicate greater fear beliefs towards the CS + than the CS- whereas negative scores indicate greater fear of the CS- than the CS+. Difference scores *(Distance from CS+) − (Distance from CS-)* were also calculated for the NRT as an index of avoidance of the CS+. Positive difference scores indicate greater distance from the CS + than the CS-, whereas negative difference scores indicate greater distance from the CS- than the CS+.

2. Results

There were 22 participants in each group (Counter-conditioning: $M_{age} = 9.09$, $SD_{age} = 1.34$, $M_{SCAS} = 24.41$, $SD_{SCAS} = 16.78$; Extinction: $M_{age} = 10.09$, $SD_{age} = 1.77$, $M_{SCAS} = 17.86$, $SD_{SCAS} = 10.67$; Control: $M_{age} = 9.32$, $SD_{age} = 0.51$, $M_{SCAS} = 18.82$, $SD_{SCAS} = 15.16$). Groups did not differ by age, ethnicity, gender, or

Table 1
Participant characteristics.

	Gender (% female)	Age	SCAS
FBQ learners ($n = 41$)	36.6	9.78 (1.39)	20.80 (13.75)
FBQ non-learners ($n = 25$)	52.0	9.04 (1.77)	19.64 (15.93)
NRT learners ($n = 45$)	44.4	9.64 (1.56)	20.91 (16.05)
NRT non-learners ($n = 21$)	38.1	9.19 (1.60)	19.19 (10.71)

Note. Standard deviations are in parenthesis. SCAS = Spence Child Anxiety Scale (Spence, 1997).

SCAS score ($ps = 0.08$ to 0.31).

2.1. FBQ learners

Given that our interest was in the effectiveness of the two procedures for reducing learned fear (i.e., extinction and counter-conditioning), the analysis for the FBQ focused only on those participants who actually showed evidence of acquiring fear on this specific index. Therefore, children were excluded from this analysis if they did not show an increase in difference score from baseline to acquisition on the FBQ, which resulted in a subsample of 41 children who were FBQ learners (26 boys, 76% Caucasian).[2] Excluded participants did not differ significantly from those included in the subgroup on ethnicity, gender, or anxiety ($ps = 0.21$-0.75), but there was a trend for included participants to be older than excluded participants ($p = 0.063$). The demographic information and anxiety scores for FBQ learners and non-learners can be found in Table 1. The final subset of participants included in the Extinction group (n = 15), CC group (n = 11), and the Control group (n = 15) did not differ by age, ethnicity, gender, or SCAS score ($ps = 0.12$ to 0.42). Although only FBQ difference scores were analysed, CS+ and CS- means and SEMs are also depicted in Fig. 1 for visual inspection.

2.1.1. FBQ acquisition

As can be seen in Fig. 2a, self-reported fear increased across time from baseline to post-acquisition. This was confirmed in a Group x Time (baseline to post-acquisition) analysis, which revealed a significant main effect of Time, $F(1, 38) = 57.58$, $p < 0.001$, $\eta_p^2 = 0.60$, but no significant Group or Time × Group interaction, $Fs < 1$.

2.1.2. FBQ test

There was a significant Time (post-acquisition to post-fear reduction) effect, $F(1, 38) = 21.82$, $p < 0.001$, $\eta_p^2 = 0.37$, but no significant Group effect, $F(2, 38) = 1.01$, $p = 0.375$, $\eta_p^2 = 0.05$. There was however, a significant Time × Group interaction, $F(2, 38) = 3.36$, $p = 0.045$, $\eta_p^2 = 0.15$. This interaction was explored using simple follow-up comparisons, which were Bonferroni-adjusted for two comparisons for each time-point ($\alpha = 0.05/2 = 0.025$). As is shown in Fig. 2a, groups were not different at post-acquisition ($ps > 0.05$) but were different at test. The Counter-conditioning group reported significantly less fear than the Control group, $t(24) = -2.70$, $p = 0.013$, $CI_{0.95}$−1.52, -0.20, but no such difference was found between the Extinction and Control groups, $t(28) = -2.10$, $p = 0.045$, $CI_{0.95}$−1.21, -0.01.

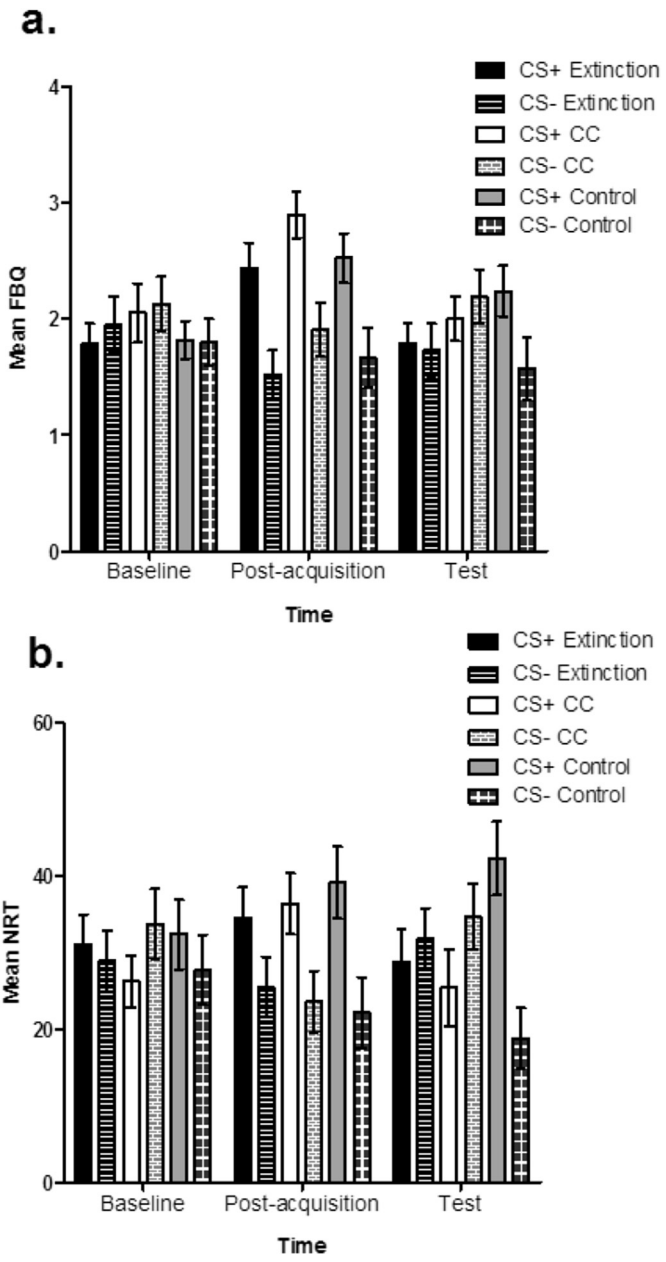

Fig. 1. Mean and SEM of CS+ and CS- score for FBQ Learners ($N = 41$) across time on (a) the FBQ and (b) the NRT. CC = counter-conditioning.

2.1.3. NRT acquisition

Avoidance across time as indexed by the NRT for FBQ learners is depicted in Fig. 2b. Avoidance increased across time from baseline to post-acquisition. This was confirmed in a Time (baseline to post-acquisition) x Group analysis, which revealed a significant main effect of Time, $F(1, 38) = 4.18$, $p = 0.048$, $\eta_p^2 = 0.099$, but no significant Group or Time × Group interaction, $Fs < 1$.

2.1.4. NRT test

Time (post-acquisition to post-reduction) x Group analyses did

[2] Analysis of the complete data set (N = 66) revealed two major differences from the subgroups. First, no differential fear reduction was detected between groups on the FBQ index (i.e., there was no significant Time × Group interaction at FBQ test, $F(2, 63) = 1.14$, $p = 0.325$, $\eta_p^2 = 0.035$). Second, although the differential fear reduction was detected between groups for the NRT, (i.e., Time × Group interaction from post-acquisition to post-reduction; $F[2, 63] = 3.28$, $p = 0.04$, $\eta_p^2 = 0.094$), extinction and CC were both significantly different from control groups in simple effects follow-up analyses (extinction: $t(42) = -2.34$, $p = 0.024$, $CI_{0.95}$−38.34, −2.84; CC: $t(42) = -3.47$, $p = 0.001$, $CI_{0.95}$−50.38, −13.35). In the overall sample including non-learners, no differences would have been detected between the fear reduction groups, potentially masking true differences.

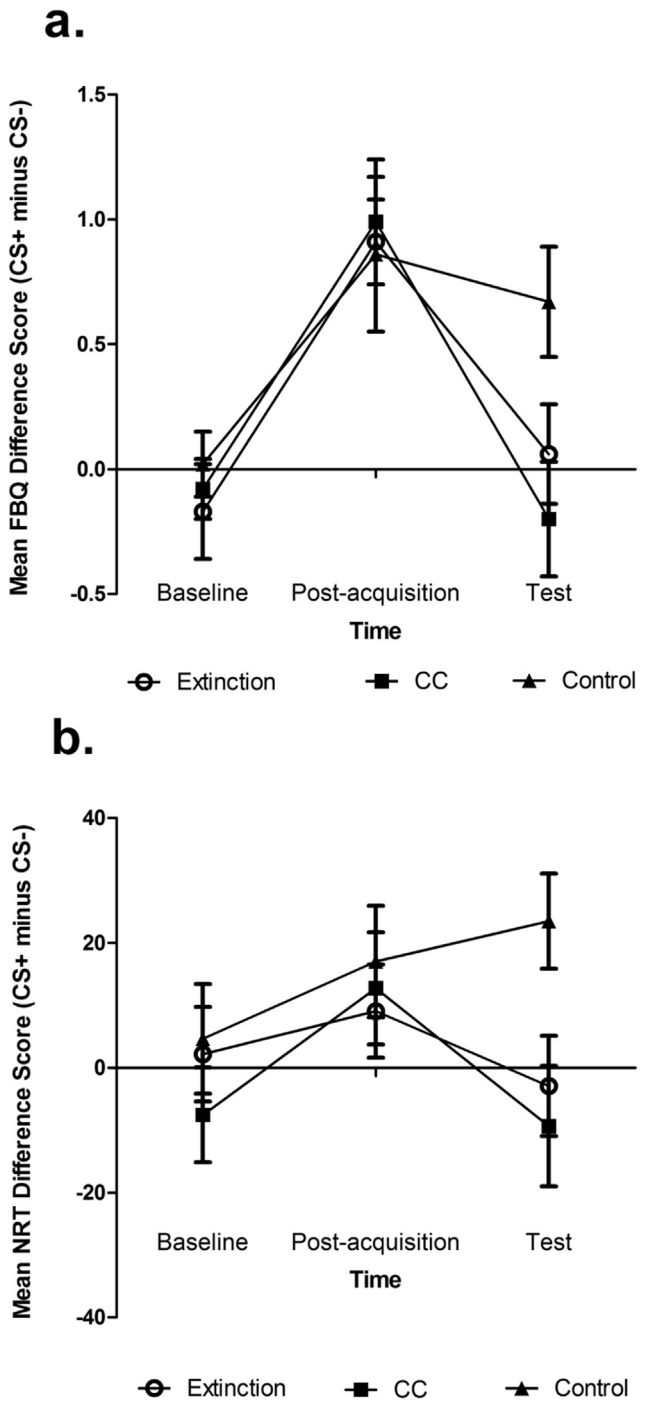

Fig. 2. Mean and SEM of difference score for FBQ Learners ($N = 41$) across time on (a) the FBQ and (b) the NRT. CC = counter-conditioning.

not reveal any significant main effects or interaction, p range: 0.06 - 0.23.

2.2. NRT learners

The following analyses excluded children who did *not* show fear acquisition on the NRT. Therefore, the analyses below were conducted on a subgroup of 45 children who were NRT learners (25 boys, 82% Caucasian) that showed an increase from baseline to post-acquisition on the NRT. Excluded participants did not differ significantly from those included in the subgroup on age, ethnicity, gender, or anxiety ($ps = 0.27$-0.79). The demographic profile and anxiety scores for NRT learners and non-learners can be found in Table 1. The NRT learners in the Extinction, Counterconditioning, and Control groups (ns = 15) did not differ by age, ethnicity, gender, or SCAS score ($ps = 0.19$ to 0.58). Although only NRT difference scores were analysed, the means and SEMs of NRT CS+ and CS- scores are depicted in Fig. 3.

2.2.1. FBQ acquisition

Changes in fear beliefs for NRT learners increased from baseline to post-acquisition at the same rate for all groups as depicted in Fig. 4a. Time (baseline to post-acquisition) x Group analyses revealed a significant main effect for Time, $F\ (1, 42) = 23.93$, $p < 0.001$, $\eta_p^2 = 0.363$, but no significant Group effect or interaction, both $Fs < 1$.

2.2.2. FBQ test

As can be seen in Fig. 4a, fear beliefs differed across time for groups. Statistical analyses showed a Time (post-acquisition to post-fear reduction) effect, $F\,(1, 42) = 10.28$, $p = 0.003$, $\eta_p^2 = 0.20$. There was no Group effect, $F\,(2, 42) = 1.29$, $p = 0.28$, $\eta_p^2 = 0.06$, or Time × Group interaction, $F\,(2, 42) = 1.20$, $p = 0.14$, $\eta_p^2 = 0.087$.

2.2.3. NRT acquisition

Avoidance across time as indexed by the NRT is depicted in Fig. 4b, and as can be seen, avoidance increased from baseline to post-acquisition at the same rate for all groups. This description was supported by statistical analyses with there being a significant main effect of Time, $F\,(1, 42) = 52.02$, $p < 0.001$, $\eta_p^2 = 0.55$. However, neither the Group effect, $F\,(2, 42) = 0.20$, $p = 0.82$, $\eta_p^2 = 0.01$, nor the Time × Group interaction, $F\,(2, 42) = 1.36$, $p = 0.26$, $\eta_p^2 = 0.06$, was statistically significant.

2.2.4. NRT test

There was a significant effect of Time (post-acquisition to post-fear reduction), $F\,(1, 42) = 7.42$, $p = 0.009$, $\eta_p^2 = 0.15$, and Group, $F\,(2, 42) = 3.37$, $p = 0.044$, $\eta_p^2 = 0.14$, as well as a Time × Group interaction, $F\ (2, 42) = 4.38$, $p = 0.019$, $\eta_p^2 = 0.17$. This interaction was explored using simple follow-up comparisons, which were Bonferroni-adjusted for two comparisons per time point ($\alpha = 0.05/2 = 0.025$). As can be seen in Fig. 4b, Groups were not different at post-acquisition, $ps > 0.05$, but were different at Test. The Counter-conditioning group exhibited significantly less avoidance than the Control group, $t(28) = -3.77$, $p = 0.001$, $CI_{0.95}$−58.26, -0.17.20, but the Extinction and Control groups were not different to one another, $t(28) = -1.66$, $p = 0.10$, $CI_{0.95}$−40.66, 4.26.

3. Discussion

Anxiety disorders typically emerge in childhood and early adolescence (Cartwright-Hatton, McNicol, & Doubleday, 2006) and treatment for these disorders involve fear inhibition. Two common methods for reducing learned fear are extinction and counter-conditioning. However, little is known about the relative efficacy of these methods in children. In the current study, we compared extinction and counter-conditioning in children aged 7–12 years using a self-report measure and an avoidance task. Only children who showed learning on one or the other index were included in the data analysis. Although both fear reduction procedures were effective, the results suggest that counter-conditioning may be more effective at reducing fear in children than extinction. Specifically, only the children in the counter-conditioning group showed less fear than the control group at test. This pattern was observed for FBQ learners on the FBQ index and NRT learners on the NRT

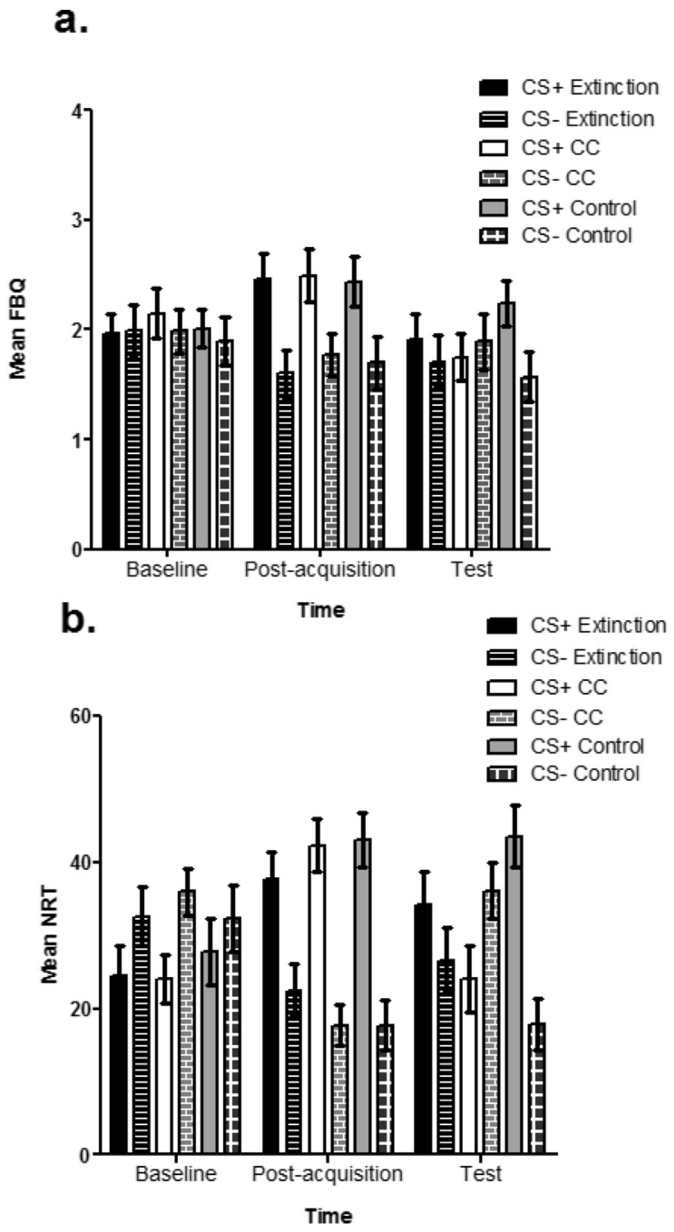

Fig. 3. Mean and SEM of CS+/CS- score for NRT Learners ($N = 45$) across time on (a) the FBQ and (b) the NRT. CC = counter-conditioning.

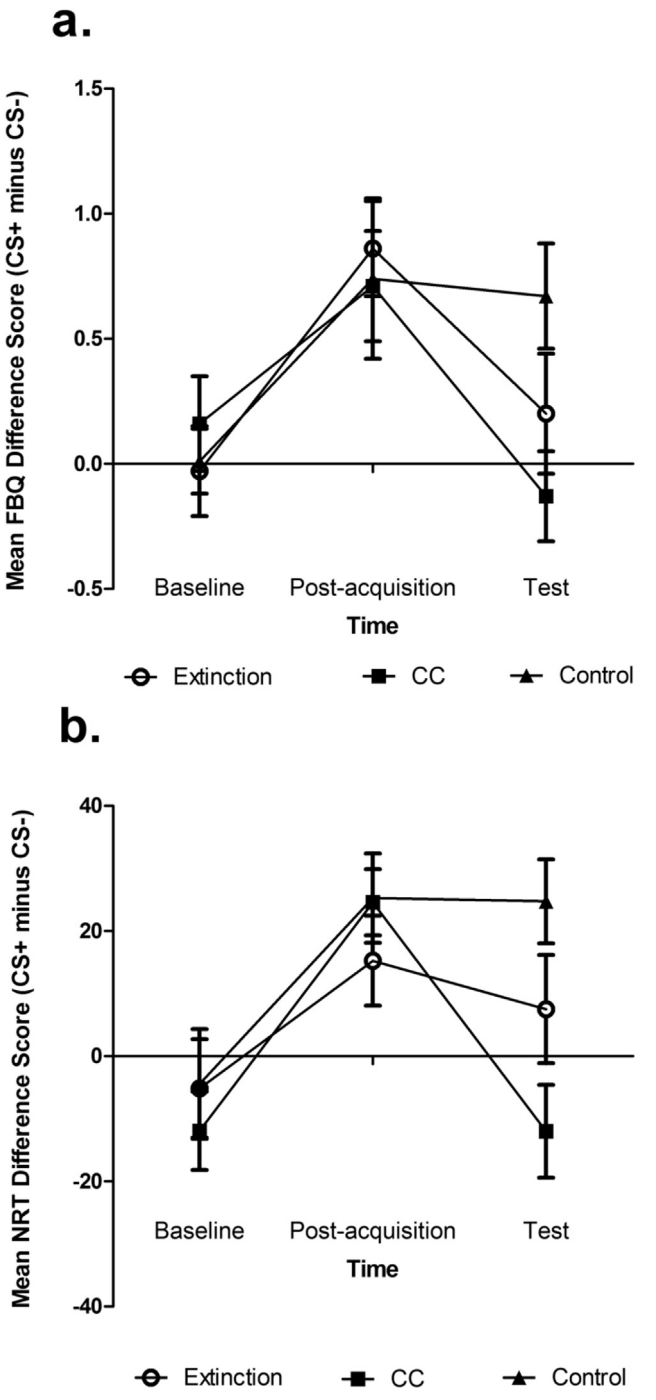

Fig. 4. Mean and SEM of difference score for NRT Learners ($N = 45$) across time on (a) the FBQ and (b) the NRT. CC = counter-conditioning.

index. These results are consistent with the one recent study that compared these two procedures in children where it was found that while counter-conditioning was effective at reducing fear on two fear indices (heart rate and avoidance) extinction did not reduce fear on any measure in children 7–12 years of age (Reynolds et al., 2017).

These findings support the limited research available indicating that counter-conditioning effectively reduces learned fear in children (Dunne & Askew, 2013; Reynolds et al., 2017), and contribute to an emerging narrative about counter-conditioning as an effective method for reducing learned fear in middle childhood. Counter-conditioning has also been shown to reduce fear in children when the procedure involves providing positive information about a feared animal (Kelly, Barker, Field, Wilson, & Reynolds, 2010; Muris, Huijding, Mayer, van As, & van Alem, 2011) rather than pairing a picture of the animal with a smiling face as was done in the present study (and also in Dunne & Askew, 2013; Reynolds et al., 2017). The current results also fit with the suggestion that counter-conditioning may be superior to extinction because, unlike extinction, counter-conditioning can alter acquired "liking/disliking" responses towards the CS (e.g., Baeyens et al., 1989; De Houwer et al., 2001; Raes & De Raedt, 2012). In the current study, children may not have expected the scary face US to appear following extinction, but they may have remained afraid because they were able to evoke an image of the scary face despite its absence. Counter-conditioning may have been more effective at reducing fear because the CS animal was paired with a smiling face that

evoked more positive emotions. Unfortunately, the current study did not include an expectancy measure to verify this explanation for the differences between counter-conditioning and extinction. The inclusion of an expectancy measure across training phases needs to be considered for future studies.

In the current cohort, approximately 18% of children did not show learning on either the FBQ or NRT following training. Further, only half of the children (i.e., 48.5%) tested in this study exhibited learned fear on both the self-report and avoidance measures. This may reflect something about the current sample, or perhaps reflect a limitation of procedures one can ethically use to condition fear in humans, especially children. The reliance on written language may have hampered the use of the FBQ as there was an age trend, with non-learners being younger than learners on this index, but no age difference was observed between the learners and non-learners on the NRT task. Importantly, one cannot ascertain whether the rates of non-learners in this study are comparable to previous studies using this same procedure as non-learners were not reported in those studies (Dunne & Askew, 2013; Reynolds et al., 2017). In fact, non-learners are not often reported in fear reduction studies with adults and children, and are unintentionally hidden in the dataset given that only group means are reported. This may be an important issue for future fear reduction studies as participants who do not learn cannot show fear reduction. If only the overall group including non-learners was analysed (see Footnote 2), no differences would have been reported between counter-conditioning and extinction groups. Therefore, while these "non-learners" may be of interest in some situations (e.g., they may be especially resilient), the inclusion of such individuals could potentially mask true group differences in fear reduction.

Another interesting finding concerns the asynchrony of fear responses during fear learning. Among the FBQ learners, no group differences were found on the NRT measure at test even though counter-conditioning was shown to be more effective on the FBQ measure. The discrepancy is intriguing given that one would expect fear measures to co-vary across all response systems (i.e., physiological, subjective report, and behavioural; Lang, Cuthbert, & Bradley, 1998) if there is a central state of fear (Davis, 1992). Other studies have also documented discordant results between self-report and other measures of learned fear in children such as skin conductance (Michalska et al., 2016) and avoidance (Reynolds et al., 2017). The lack of co-variation may be due to one measure being less valid than the other. For example, self-report may be more vulnerable to demand characteristics than avoidance because it is easier for the children to guess the direction of expected effects. Another possibility is that children may have experienced more difficulties understanding the NRT, or imagining themselves as a LEGO figurine on a nature reserve to show avoidance/approach. Another limitation of the study is that physiological measures such as heart rate and skin conductance responses were not included. These measures are valuable because they do not rely on children's verbal abilities, or comprehension of the task, and therefore, may be more accurate in measuring fear learning. Future studies will need to consider the inclusion of these measures.

Despite these limitations, the results suggests that while extinction and counter-conditioning both reduce fear in children exposed to a Pavlovian conditioning preparation with a vicarious learning component, the counter-conditioning procedure is potentially more effective. This finding has potential implications for the treatment of childhood anxiety disorders like specific phobia as it suggests that integration of counter-conditioning as an adjunct to gold-standard interventions may lead to better treatment outcomes. Further, as counter-conditioning is likely to be more appealing and acceptable for anxious children, program adherence and compliance is likely to be improved as well. Further research is needed to explore the application of counter-conditioning to clinical populations.

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