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Stimulus Fear Relevance and the Speed, Magnitude, and Robustness of Vicariously

Learned Fear

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Abstract

Superior learning for fear-relevant stimuli is typically indicated in the laboratory by faster acquisition of fear responses, greater learned fear, and enhanced resistance to extinction. Three experiments investigated the speed, magnitude, and robustness of UK children's (6-10 years; $N = 290$; 122 boys, 168 girls) vicariously learned fear responses for three types of stimuli. In two experiments, children were presented with pictures of novel animals (Australian marsupials) and flowers (fear-irrelevant stimuli) alone (control) or together with faces expressing fear or happiness. To determine learning speed the number of stimulus-face pairings seen by children was varied (1, 10, or 30 trials). Robustness of learning was examined via repeated extinction procedures over 3 weeks. A third experiment compared the magnitude and robustness of vicarious fear learning for snakes and marsupials. Significant increases in fear responses were found for snakes, marsupials and flowers. There was no indication that vicarious learning for marsupials was faster than for flowers. Moreover, vicariously learned fear was neither greater nor more robust for snakes compared to marsupials, or for marsupials compared to flowers. These findings suggest that for this age group stimulus fear relevance may have little influence on vicarious fear learning.

Keywords: anxiety, vicarious learning, childhood fears, preparedness, extinction

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Learned Fear

Seligman (1971) explained the non-random distribution of fear, in which some types

of fear are more common than others, in terms of evolutionary-based biological

'preparedness' and typically a distinction is now made between 'fear-relevant' ('prepared')

and 'fear-irrelevant' (unprepared) stimuli. Phylogenetic fear-relevant stimuli such as snakes

and spiders are said to be stimuli that presented a threat to human ancestors and avoiding

these stimuli may have aided survival. Therefore, individuals that learned to fear them

quickly and easily would have been more likely to survive and pass on their genes than those

who did not. Fear-irrelevant stimuli on the other hand, are stimuli such as flowers that did

not pose such a threat to our ancestors. Seligman argued that stimulus preparedness enhances

learning of fear-related associations during a traumatic learning event with phylogenetic fear-

relevant stimuli. Associations between a fear-relevant stimulus (conditioned stimulus; CS)

and a negative outcome (unconditioned stimulus; US) are believed to be less cognitive or

rational than is the case for fear-irrelevant stimuli, and are argued to occur more readily and

be more robust (Mineka & Öhman, 2002; Öhman & Mineka, 2001; Seligman, 1971).

Typically, laboratory evidence for these 'selective associations' is said to occur when

learning for a stimulus shows one or more of several features, including: a) a larger

conditioned fear response; b) faster acquisition (learning in fewer trials); and c) is more

persistent, showing enhanced resistance to extinction (see e.g., Mineka & Öhman, 2002;

Öhman & Mineka, 2001).

One way that children can learn to fear a stimulus is vicariously, through observation

of another person's (a model) response to the stimulus (Rachman, 1977). It has been argued

that vicarious learning is a form of CS-US associative learning (Askew & Field, 2007, 2008;

Bandura, 1969; Mineka & Cook, 1986, 1993; Reynolds, Field, & Askew, 2015) in which the model's response acts as the US and becomes associated with the animal or object CS. Vicarious fear-learning has been convincingly demonstrated in experiments with adults (e.g., Berger, 1962; Golkar & Olsson, 2016; Olsson et al., 2016; Olsson & Phelps, 2004; Vaughan & Lanzetta, 1980) and monkeys (e.g., Cook & Mineka, 1990; Cook, Mineka, Wolkenstein, & Laitsch, 1985; Mineka & Cook, 1993; Mineka, Davidson, Cook, & Keir, 1984). Given that specific fears and phobias often begin during childhood (Öst, 1987; Öst & Treffers, 2001), this is likely to be a particularly informative period in which to research their onset. Evidence with children has shown that vicarious learning can lead to changes in all three of Lang's (1968) fear response systems: verbal-cognitive, behavioral avoidance, and physiological responses (e.g., Askew, Çakir, Põldsam, & Reynolds, 2014; Askew & Field, 2007; Askew, Kessock-Philip, & Field, 2008; Askew, Reynolds, Fielding-Smith & Field, 2016; Dubi, Rapee, Emerton, & Schniering, 2008; Dunne & Askew, 2013, 2016; Gerull & Rapee, 2002; Reynolds, Field & Askew, 2017); as well as attentional bias (Reynolds, Field, & Askew, 2014; Reynolds, Field, & Askew, in press) for animals.

In a series of seminal studies, Mineka, Cook, and colleagues demonstrated that laboratory-reared rhesus monkeys that were not initially afraid of snakes rapidly learned fear of snakes from observing snake-fearful monkeys (e.g., Cook et al., 1985; Mineka & Cook, 1993; Mineka et al., 1984). This vicarious fear learning effect was found for fear-relevant stimuli such as toy snakes but not for fear-irrelevant stimuli such as flowers (Cook & Mineka, 1989; 1990). Similar evidence of superior conditioning for fear-relevant stimuli also comes from a range of classical conditioning procedures with adults (see Öhman & Mineka, 2001 for an overview). The evidence, however, for selective associations in human vicarious learning is less clear. Using a paradigm in which toddlers saw their parents responding negatively to stimuli, Dubi et al. (2008) found no difference in learned fear and avoidance for

fear-relevant (rubber snake or spider) and fear-irrelevant (rubber flower or mushroom) stimuli. Similarly, Askew, Dunne, Özdil, Reynolds, and Field (2013) found that the magnitude of vicariously learned fear responses was not affected by stimulus fear relevance. Askew and colleagues presented 6- to 11-year-olds with images of fearful adult faces alongside images of stimuli with low to high levels of fear relevance: flowers, worms, marsupials, caterpillars, and snakes. Vicariously learned increases in fear-related responses were no different for flowers, marsupials, caterpillars, and snakes; only worms showed lower levels of learning on some, but not all, measures. Together, these findings appear to suggest that fear relevance may be bypassed when children observationally learn fear-related information about stimuli from adults.

Evidence from vicarious learning in children then, has found no evidence of larger learned responses for stimuli of greater fear relevance. However, it remains possible that vicariously learned fear for these stimuli is more rapid or robust, either of which would also be indicative of selective associations. For example, direct conditioning studies with adults have sometimes shown similar magnitudes of fear acquisition for fear-relevant (e.g. snakes, spiders, angry faces) and fear-irrelevant (e.g. flowers, mushrooms, happy faces) stimuli, but found superior resistance to extinction for fear-relevant stimuli (Öhman & Dimberg, 1978; Öhman, Fredrikson, Hugdahl, & Rimmö, 1976). Similarly, Hygge and Öhman (1978) found that although adults' vicariously learned fear responses were initially similar, they immediately extinguished for fear-irrelevant stimuli (mushrooms, berries, and flowers) but not for fear-relevant stimuli (snakes, spiders, and rats). Other evidence shows direct conditioning of fear in adults in a single CS-US pairing trial for fear-relevant but not fear-irrelevant stimuli (e.g., Öhman, Eriksson, & Olofsson, 1975). Thus, as well as the magnitude of fear learning, the speed and robustness of vicarious fear learning for stimuli of differing fear relevance should also be investigated in children. The three experiments described here

examined all three laboratory characteristics of selective associations. Experiment 1

compared the magnitude and speed of vicarious fear-learning in children for two types of

stimuli likely to be of differing fear relevance: novel (unknown to the child) animals

(marsupials: a quoll, quokka, and cuscus) and flowers (a red avens, willow gentian, and

dotted loosestrife). It also examined whether learning is more lasting for marsupials

compared to flowers. Experiment 2 investigated robustness of learning for the marsupial and

flower stimuli in more detail, comparing robustness of learning in children following three

extinction procedures over a 3 week period. Finally, given that marsupials are not established

fear-relevant stimuli, Experiment 3 compared magnitude of learning and resistance to

extinction and counterconditioning following vicarious fear learning for marsupials and well-

established fear-relevant stimuli: snakes (keelback, pattoni, and boomslang).

Experiment 1

In an adaptation of Askew and Field's (2007) vicarious learning paradigm, two

groups of children saw either three marsupial (higher fear relevance) or three flower (lower

fear relevance) CSs together with emotional face USs in a series of marsupial-face (CS-US)

'pairings': one marsupial or flower CS with fearful faces (fear-paired), one CS with happy

faces (happy-paired), and one alone with no faces (unpaired control). In addition, in order to

investigate speed of learning, children were divided into three further groups that saw

different numbers of CS-US trials: 1, 10, or 30 trials, to compare speed of learning. Measures

of children's fear beliefs for the CSs were taken before and after learning and avoidance

preferences were measured after learning. Follow-up measures were also taken 1 week later

to investigate whether learning was more persistent for the animals than the flowers.

The marsupials and flowers were chosen because they are unfamiliar to U.K. children,

so children were unlikely to have an existing learning history for them and therefore no prior

threat-related beliefs or expectations for them. This is important because prior expectancies that a learning event involving a CS will have a negative outcome (US) are known to enhance fear learning, increasing the speed of learning between the CS and an aversive US, and producing associations that are more resistant to extinction (see Davey, 1992; 1997). US expectancy biases have not only been found for phylogenetic (snakes and spiders) but also ontogenetic (gun and electricity outlet) fear-relevant stimuli (Honeybourne, Matchett, & Davey, 1993), showing that expectancies can be learned via cultural transmission. Threat-related verbal information, for example, has been shown to increase children's expectancies in relation to novel marsupials (Field, Lawson, & Banerjee, 2008). Thus one limitation of typical conditioning paradigms with fear-relevant and fear-irrelevant stimuli is that participants are likely to have prior expectancies for the stimuli used. Learning for stimuli that are unknown to participants may produce different results to studies that use more obvious fear-relevant stimuli such as snakes or spiders, for which children in this age group are already likely to have existing fear-related beliefs and learning histories. It was considered important for the current study that children would have limited familiarity with the stimuli used but would also be old enough to be at an age when fears of this kind typically begin.

Based on Dubi et al.'s (2008) and Askew et al.'s (2013) findings, it was predicted that there would be similar increases in children's fear-related responses for fear-paired marsupials and flowers. However, based on evidence from human classical conditioning paradigms (see Öhman & Mineka, 2001), it seemed likely that learning might occur more rapidly (in fewer trials) for marsupial stimuli because of their higher fear relevance compared to flowers. It also seemed likely that learning for marsupials would persist longer than for flowers because classical conditioning procedures show greater robustness for fear-relevant stimuli compared with fear-irrelevant stimuli (see Öhman & Mineka, 2001). A final effect of

more general theoretical interest was whether vicarious fear learning over a greater number of

trials would lead generally to greater and more robust fear-related responses compared with

learning in fewer trials.

Method

Participants. Participants were 140 children (53 boys, 87 girls) aged 6–10 years (M

= 8.86 years, SD = 1.29 years). Previous research indicates that normal developmental fears

in this age group often focus on animals (Field & Davey, 2001). Children were recruited

from schools in southwest London, U.K. All parents and caregivers gave informed consent

and children gave their verbal assent. Children were randomly assigned to either the

marsupial (n = 74; 29 boys and 45 girls) or flower (n = 66; 24 boys and 42 girls) group. In

addition, children within each group were divided into a further three groups receiving

different numbers of pairing trials: marsupial-1 trial (n = 25), marsupial-10 trials (n = 24),

marsupial-30 trials (n = 25), flower-1 trial (n = 22), flower-10 trials (n = 21), and flower-30

trials (n = 23). Age did not vary significantly across groups, $F(5, 134) = 1.53$, $p = .19$ and

there was no evidence of an association between gender and group, $\chi^2(5, N = 140) = 1.42$, $p =$

.92.

Materials.

CSs. Three color images (400 × 400 pixels) of each of three Australian marsupials

(the quoll, quokka, and cuscus), typically unknown to U.K children, were used as novel

marsupial CSs (Askew & Field, 2007; Field & Lawson, 2003); thus there were nine different

images in total. These animals were chosen because U.K. children are generally unaware of

them and because they have been successfully used in previous similar vicarious learning

studies (e.g., Askew & Field, 2007; Askew et al., 2008, 2013, 2014; Dunne & Askew, 2013;

Reynolds et al., 2014, 2017). In addition, there were three different images (each measuring

400×300 pixels) of each of three flowers (a red avens, willow gentian, and a dotted loosestrife); nine in total. These flower CSs were similarly chosen because they are uncommon in the U.K. and because two of the flowers, the red avens and dotted loosestrife, had already been used successfully in a similar experiment by Askew et al. (2013).

Face USs. Ten models were chosen at random from the set of 31 adult female models used by Dunne and Askew (2013, 2016). Each model was individually taught how to pose fearful and happy faces using the guidelines and descriptions of Izard (1971), and Ekman and Friesen (1975) and faces were rated for emotional accuracy by a sample of adults and children (see Dunne & Askew, 2013, for details). Three fearful and three happy color portrait images of each model, with a uniformly plain background (300×400 pixels) were used; 60 images in total. As with marsupial and flower images, more than one example of each type of image was used to reduce the possibility that children saw one particular image of an adult being repeatedly paired with a specific image of a marsupial or a flower.

Fear Beliefs Questionnaire (FBQ). A version of the FBQ (Field & Lawson, 2003), used successfully by Askew et al. (2013) to measure children's fear beliefs for marsupial and flower CSs, was also used here. Children are asked in the FBQ about how they would feel in seven hypothetical situations with each marsupial or flower (e.g., "Would you be happy if you found a cuscus/quokka/quoll/red avens/dotted loosestrife/willow gentian in your garden?"). They responded to 21 questions in total on a 5-point Likert scale (0 = *'No, not at all'*; 1 = *'No, not really'*; 2 = *'Don't know/Neither'*; 3 = *'Yes, probably'*; 4 = *'Yes, definitely'*). An average fear beliefs score from 0 to 4 was calculated for each marsupial or flower, with 4 being the highest level of fear beliefs. Internal consistencies were in line with previous studies (e.g. Askew et al., 2008; Field, 2006), meeting or approaching Kline's (1999) recommended .70 threshold: prior to vicarious learning, Cronbach's α = .82 for the cuscus subscale, .75 for the quokka subscale, .81 for the quoll subscale, .72 for the red avens

subscale, .80 for the dotted loosestrife subscale, and .68 for the willow gentian subscale. After vicarious learning α = .91, .88, and .89 for the marsupials, and .87, .90, and .84 for the flowers respectively. One week later Cronbach's α = .89 for the cuscus subscale, .76 for the quokka subscale, .86 for the quoll subscale, .81 for the red avens subscale, .82 for the dotted loosestrife subscale, and .77 for the willow gentian subscale.

Distraction Task. A simple custom-written Microsoft PowerPoint-based multi-level maze game was used as a distraction task. Children had to navigate the mouse through a series of obstacles to gain access to the next level of the game. A stopwatch was used to ensure the distraction task was performed for the correct length of time which varied depending on the trial group children belonged to in order that the time between the pre- and post-vicarious learning FBQs was always similar.

Nature Reserve Task (NRT). The NRT (Field & Storksen-Coulson, 2007) was used to measure children's avoidance preferences for marsupials and flowers. Children were asked to imagine that a green board (45 cm × 60 cm) was a nature reserve. An image of one of the marsupials or flowers children had seen during vicarious learning was placed at one end of the rectangular board and children were asked to place a Playmobil figure representing themselves onto the board in the location where they would feel most at ease. This procedure was then repeated for the second and third CSs. The distance from the child's figure to each CS was measured as an indication of children's avoidance preference for that CS (marsupial or flower).

Procedure. The procedure was computerized (Field, 2010) in Visual Basic.net and presented to children on an RM 4300 laptop with a 15.6" screen. Children were randomly allocated to one of two CS groups, marsupials or flowers, and then completed the first FBQ about their CSs. Next, all children completed a distraction task and then saw the vicarious

learning procedure. During vicarious learning, children in the marsupial group saw pairing

trials in which one marsupial was presented together with fearful faces, one marsupial with

happy faces, and the third marsupial on its own as an unpaired control condition. Children in

the flower group saw flowers instead of marsupials. A single CS-US pairing trial consisted

of a CS (marsupial or flower) being presented on the screen alone for 1s and a further 1s

together with a US (face) on the opposite side of the screen, while unpaired trials consisted of

the CS being presented alone for 2s. The type of facial expression paired with each type of

marsupial or flower was counter-balanced across children. In addition, each CS group was

subdivided into three further trial groups, which determined the number of pairing trials

children saw during vicarious learning: 1, 10, or 30 trials. Thus there were essentially six

groups in all: marsupial-1 trial, marsupial-10 trials, marsupial-30 trials, flower-1 trial, flower-

10 trials, and flower-30 trials. As the number of trials varied between groups, children

undertook a distraction task before vicarious learning to ensure that all groups had the same

time interval between completing the pre- and post-learning FBQs. The length of time spent

on the distraction task depended on the trial group children were assigned to: 9 mins for the 1

trial groups; 6 mins for the 10 trials groups; and 1 min for the 30 trials group. Thus, for

example, children in the marsupial-1 trial group were given a 9 min distraction task and then

presented with each of the three marsupials for a single trial only; one marsupial was seen

once with a happy face, one marsupial was seen once with a fear face, and one marsupial was

seen once unpaired (control). Following vicarious learning, children completed the FBQ a

second time and the first NRT. One week later the FBQ and NRT were administered again.

Finally, children were fully debriefed using games, puzzles and correct information about the

marsupials or flowers they had seen.

Results

Fear Beliefs.

Vicarious acquisition. FBQ scores were compared pre- and post-vicarious learning. Figure 1 shows that mean fear beliefs for fear-paired stimuli were higher post-learning than pre-learning. In contrast, fear beliefs for happy-paired stimuli decreased post-learning compared to baseline. Unpaired fear beliefs remained similar across all time points: pre-learning, post-learning and 1 week later. A four-way 2(time: pre-learning vs. post-learning) × 3(pairing type: fear, happy, unpaired) × 2(CS group: marsupials vs. flowers) × 3(trial group: 1, 10, 30) mixed ANOVA with repeated measures for the first two variables was performed on fear belief scores. The important (Greenhouse-Geisser adjusted) time × pairing type interaction was significant, $F(1.69, 226.78) = 47.38$, $p < .001$, $\eta^2p = .26$ (95% CIs [0.166, 0.347]), indicating that vicarious learning led to changes in fear beliefs for CSs that were different depending on the type of face children saw them with. Planned comparisons comparing baseline fear beliefs and fear beliefs following vicarious learning showed a significant increase following fear face-pairing, $F(1, 134) = 66.01$, $p < .001$, $\eta^2p = .33$ (95% CIs [0.205, 0.438]) and a significant decrease after happy face-pairing, $F(1, 134) = 22.34$, $p < .001$, $\eta^2p = .14$ (95% CIs [0.050, 0.251]), compared with changes for unpaired CSs. Thus, fear beliefs had increased due to fear vicarious learning and decreased following positive vicarious learning.

The time × pairing type × CS group × trial group interaction was non-significant, $F(8, 536) = 0.70$, $p = .69$, $\eta^2p = .010$ (95% CIs [0, 0.016]). All other interactions were non-significant, including the time × pairing type × trial group interaction, $F(3.38, 226.78) = 1.27$, $p = .28$, $\eta^2p = .019$ (95% CIs [0, 0.053]), and the time × pairing type × CS group interaction, $F(1.69, 226.78) = 2.38$, $p = .10$, $\eta^2p = .017$ (95% CIs [0, 0.061]). This shows that the fear relevance of the CS (marsupial or flower) and the number (1, 10, and 30) of CS-US pairing trials children saw had no effect on the magnitude of vicarious learning. The lack of four-way interaction indicates that learning was not faster for one CS type than another, and given

the small magnitude of effect sizes, it is highly unlikely that this nonsignificance was simply the result of a lack of power.

Correlational analysis showed that there was a significant correlation between age and overall changes in fear beliefs due to negative pairing, $r_s(138) = .18$, $p = .031$, with greater age associated with greater increases in fear beliefs. However, this effect was relatively small. There were also gender differences in increases in fear beliefs. On average, girls ($M = 0.81$, $SD = 1.21$) showed significant greater increases in fear beliefs than boys ($M = 0.28$, $SD = 1.19$), $t(183) = 2.56$, $p = .012$, $d = 0.45$.

1-week follow-up. Figure 1 shows that mean fear beliefs remained higher than baseline 1 week after learning. Similarly, fear beliefs for happy-paired stimuli were still lower 1 week later than at baseline. An identical ANOVA analysis comparing post-vicarious learning FBQ scores to scores 1 week later supported this. Only effects that include time as a variable are of interest here. Of these, all were nonsignificant except for the time × pairing type interaction, $F(2, 268) = 3.81$, $p = .023$, $\eta^2 p = .028$ (95% CIs [0.0001, 0.072]) which indicated that fear beliefs for stimuli changed over one week depending on the face children had seen them with. Planned comparisons found that fear beliefs had significantly decreased for fear-paired CSs, $F(1, 134) = 7.05$, $p = .009$, $\eta^2 p = .05$ (95% CIs [0.003, 0.137]) but remained constant for happy-paired CSs, $F(1, 134) = 2.00$, $p = .16$, $\eta^2 p = . 015$ (95% CIs [0, 0.077]), compared to unpaired CSs. Thus, positive vicarious learning was more robust than fear vicarious learning. Nonsignificant interactions between time × pairing type effects with the CS type and number of pairings indicated that these effects were identical for marsupials and flowers, $F(2, 268) = 0.25$, $p = .78$, $\eta^2 p = .002$ (95% CIs [0, 0.018]), and for 1, 10, or 30 pairings, $F(4, 268) = 0.12$, $p = .98$, $\eta^2 p = .002$ (95% CIs [0, 0.007]). Effects were so small as to be negligible, indicating that it was highly unlikely that lack of power could explain nonsignificance.

Not all children showed evidence of fear-related acquisition during the vicarious fear learning phase. Therefore, an additional identical analysis investigated fear reduction in only those children ($n = 82$) that had shown increases in fear beliefs post-learning. The time × pairing type interaction was significant, $F(2, 152) = 13.72$, $p < .001$, $\eta^2p = .15$ (95% CIs [0.153, 0.057]), which again indicated a significant pairing type-related reduction in fear beliefs for stimuli over time. Planned comparisons confirmed that there was a significant reduction in fear beliefs at 1 week follow-up ($M = 2.52$, $SD = 0.99$) compared to post-learning ($M = 3.07$, $SD = 0.77$) for fear-paired CSs compared to unpaired CSs, $F(1, 76) = 29.51$, $p < .001$, $\eta^2p = .28$. All other effects were nonsignificant except for the main effects of time and pairing type, and the time × CS group interaction, which do not have meaningful theoretical implications here. Therefore, this confirmed that fear reduction occurred over 1 week, was the same for animals and flowers, and was not affected by the number of pairings seen during acquisition.

Avoidance preferences.

Vicarious acquisition. Figure 2 shows mean distances (cm) from marsupial and flower CSs to the figures children placed on the board. A three-way 3(pairing type: fear, happy, unpaired) × 2(CS group: marsupials vs. flowers) × 3(trial group: 1, 10, 30) mixed ANOVA analysis was performed on NRT scores. The crucial main effect of pairing type was significant, indicating that vicarious learning affected how far away children placed themselves from flowers and marsupials in the nature reserve after vicarious learning, $F(1.89, 252.95) = 11.88$, $p < .001$, $\eta^2p = .08$ (95% CIs [0.026, 0.148]). Planned comparisons showed children placed themselves farther away from fear-paired CSs, $F(1, 134) = 18.16$, $p < .001$, $\eta^2p = .12$ (95% CIs [0.035, 0.224]), and closer to happy-paired CSs, $F(1, 134) = 12.09$, $p =.001$, $\eta^2p = .083$ (95% CIs [0.016, 0.181]) compared to unpaired control stimuli. All other main effects and interactions were nonsignificant, including the pairing type × CS group ×

trial group interaction, $F(4, 268) = 0.93$, $p = .45$, $\eta^2p = .014$ (95% CIs [0, 0.038]), pairing type $\times$ CS group interaction, $F(2, 268) = 2.11$, $p = .12$, $\eta^2p = .016$ (95% CIs [0, 0.052]), and pairing type $\times$ trial group interaction, $F(4, 268) = 1.04$, $p = .39$, $\eta^2p = .015$ (95% CIs [0, 0.041]). These showed that the effect of vicarious learning was the same for marsupials and flowers, and for 1, 10 or 30 pairings, and the very small effect sizes suggest that his cannot be explained by inadequate power.

Correlational analysis found no relationship between ages and changes in avoidance preferences for negatively paired animals. Neither was there a significant difference between girls and boys in changes in avoidance preferences for the fear-paired animal.

1-week follow-up.   An identical analysis was conducted at follow-up 1 week later. The main effect of pairing-type showed that avoidance preferences were also different at 1 week depending on pairing type, $F(1.92, 256.64) = 15.84$, $p < .001$, $\eta^2p = .11$ (95% CIs [0.042, 0.176]). Planned comparisons showed that avoidance was significantly greater for fear-paired stimuli, $F(1, 134) = 33.57$, $p < .001$, $\eta^2p = .20$ (95% CIs [0.092, 0.313]), and significant lower for happy-paired stimuli, $F(1, 134) = 12.69$, $p = .001$, $\eta^2p = .09$ (95% CIs [0.017, 0.185]), than unpaired control stimuli. All other main effects and interactions were non-significant, showing that robustness of children's avoidance preferences over time was no different for animal and marsupials, and number of pairing trials also did not affect this. An analysis could not be conducted for only those children that showed increased avoidance after vicarious learning because baseline measures of avoidance preferences were not taken.

Experiment 2

Experiment 1 found no effect of stimulus type on the speed (number of trials) or magnitude of vicariously learned fear beliefs and avoidance preferences. There was also no evidence that fear-related learning for fear-irrelevant flowers was any less robust than for

marsupials: learned fear beliefs were significantly reduced at 1 week for both stimuli, and learned avoidance preferences were still detectable after 1 week for both stimuli. However, robustness was only examined as persistence of vicarious learning effects over time, and it may still be the case that animals show additional robustness to extinction procedures compared to flowers. Extinction refers to the gradual weakening of a previously established conditioned response by repeated presentation of the CS on its own, leading to the learned behavior (conditioned response; CR) reducing or disappearing; that is, subsequent exposures to a CS in the absence of the US should weaken the association between the CS and the US with a corresponding reduction in the CR (see Bouton, 2004). Resistance to extinction is demonstrated when there is no reduction in conditioned response to the CS following CS-only presentations.

In research comparing characteristics of direct aversive learning for stimuli considered prepared and fear-relevant, such as snakes or spiders, with fear-irrelevant stimuli such as flowers and mushrooms, resistance to extinction is one of the most persistently observed effects (e.g., Cook, Hodes, & Lang, 1986; Fredrikson & Öhman, 1979; Öhman & Dimberg, 1978; Öhman et al., 1976; Öhman & Mineka, 2001). However, others such as McNally and Foa (1986) and Merckelbach, van der Molen, and van den Hout (1987) reported no evidence of superior resistance to extinction for fear-relevant stimuli. McNally and Foa (1986) found that the only predictor of resistance to extinction was strength of conditioning; although, Öhman and Mineka (2001) have attributed failures to find superior resistance to methodological differences.

Given previous findings, Experiment 2 examined whether vicariously acquired fear-related responses for stimuli of greater fear relevance would show greater resistance to extinction. At one week intervals for 3 weeks following vicarious learning, children were exposed to three extinction procedures consisting of presentations of the conditioned stimulus

(marsupials or flowers) in the absence of the unconditioned stimulus (emotional faces). One week intervals were chosen to parallel the timeline of Experiment 1. However, one week may have been too short to measure persistence in Experiment 1 and similarities between stimuli in the perseverance of fear responses could be due to this.

Changes in children's fear beliefs and avoidance preferences for marsupials or flowers were again measured by FBQ and NRT. But this time pre-vicarious learning NRT measures were also taken so that avoidance preferences post-learning could be compared within each child to baseline levels. This meant existing avoidance preferences could be taken into account and the possibility that differences across conditions were already present prior to learning ruled out, although this was not expected given that CSs and faces were counterbalanced. Based on previous research, children were again expected to show a marked increase in fear-related beliefs and avoidance preferences for marsupials and flowers seen together with pictures of adult fear faces. In addition, much of the classical conditioning literature suggests superior resistance to extinction should be observed for stimuli of higher fear relevance. Given the apparent similarities between direct conditioning and vicarious learning mechanisms (see Askew & Field, 2008), similar effects might be predicted here for animals compared to flowers.

Method

Participants. Participants were 66 children (23 boys, 43 girls) aged 6-10 years ($M =$ 8.81 years, $SD = 1.01$ years) recruited from local schools in southwest London, UK. All had parental consent and gave verbal assent. As in Experiment 1, children were randomly assigned to the marsupial ($n = 34$, 16 boys and 18 girls) or flower ($n = 32$, 7 boys and 25 girls) CS groups. There was no association between gender and group, $\chi^2(1, N = 66) = 3.56$, $p = .059$. Children in the flower group ($M = 108.75$ months, $SD = 11.40$) were on average 6

months older than children in the marsupial group ($M = 102.85$ months, $SD = 12.16$); a marginally significant difference, $t(64) = 2.03$, $p = .047$.

Materials. Marsupial, flower, and face images were identical to Experiment 1. Measures used were also identical. Internal consistencies for the FBQ were once again found to be acceptable: before vicarious learning, scale reliabilities were Cronbach's $\alpha = .73$ for the cuscus subscale, .66 for the quokka subscale, .71 for the quoll subscale, .66 for the red avens subscale, .79 for the dotted loosestrife subscale, and .74 for the willow gentian subscale. Post-vicarious learning they were: .80, .75, and .82 for the marsupials, and .93, .93, and .87 for the flowers respectively. At 1 week extinction Cronbach's α's were .83, .76 and .78 for marsupials, and .90, .84, and .85 for flowers; at 2 weeks extinction, .84, .71, and .79 for marsupials, and .90, .92, and .84 for flowers; and at 3 weeks extinction, .84, .72, and .84 for marsupials, and .91, .90, and .87 for flowers respectively.

Procedure. The procedure was similar to Experiment 1 except that in addition to the first FBQ, children were also asked to complete a pre-vicarious learning NRT. Following these baseline measures, all children saw 10 CS-US pairings for each animal or flower during vicarious learning: 10 marsupials or flowers with fear faces (fear-paired), 10 marsupials or flowers with happy faces (happy-paired), and 10 marsupials or flowers with no faces (unpaired control). Next, children completed the FBQ and NRT a second time. One week later, children took part in the first extinction procedure. Depending on the CS group they were in, they were shown all 30 marsupial or flower CS images again but this time alone, without any accompanying face US. They then completed a third FBQ and NRT to detect changes in fear-related beliefs or avoidance preferences caused by the extinction procedure. A second identical extinction procedure was performed 2 weeks after the initial vicarious learning task and FBQ and NRT measures were taken again. At 3 weeks, the final extinction

procedure and FBQ and NRT measures were conducted. Children were fully debriefed and

given games and puzzles with correct information regarding the stimuli they saw.

Results

Fear beliefs.

Vicarious acquisition. The effect of vicarious learning on fear beliefs was determined

via a three-way 2(time: pre-learning vs. post-learning) × 3(pairing type: fear, happy,

unpaired) × 2(CS group: marsupials vs. flowers) mixed ANOVA with repeated measures on

the first two variables. The time × pairing type interaction critical for indicating successful

vicarious learning was significant, $F(2, 128) = 11.75$, $p < .001$, $\eta^2 p = .16$ (95% CIs [0.051,

0.261]). Planned comparisons were used to examine this effect in more detail, revealing that

fear beliefs significantly increased for fear-paired CSs, $F(1, 64) = 19.04$, $p < .001$, $\eta^2 p = .23$

(95% CIs [0.071, 0.387]), and significantly decreased for happy-paired CSs, $F(1, 64) = 10.59$,

$p = .002$, $\eta^2 p = .14$ (95% CIs [0.022, 0.297]). In contrast, the time × pairing type x CS group

interaction was nonsignificant, $F(2, 128) = 1.41$, $p = .25$, $\eta^2 p = .02$ (95% CIs [0, 0.083]).

This meant that negative and positive vicarious learning were successful for increasing and

decreasing fear beliefs, and this effect was the same for marsupials and flowers (see Figures

3a and 3b). The small effect size indicated that this was not likely to be the result of power

issues.

A correlational analysis showed that there was a positive significant correlation

between age and changes in fear beliefs for the fear-paired animal, $r(64) = .29$, $p = .019$,

showing that increases in fear beliefs were larger in older children. Increases in fear beliefs

were no different for boys and girls.

Fear reduction. A three-way 4(time: post-learning, 1 week extinction, 2 weeks

extinction, and 3 weeks extinction) × 3(pairing type: fear, happy, unpaired) × 2(CS group:

marsupials vs. flowers) mixed ANOVA was performed on fear belief scores. There was no evidence that fear beliefs decreased at all due to extinction over the entire 3 week period because the time × pairing type interaction was nonsignificant, $F(4.71, 301.15) = 1.45$, $p = .21$, $\eta^2p = .022$ (95% CIs [0, 0.050]). In addition, a nonsignificant three-way interaction indicated that learned fear beliefs were similarly robust for both marsupials and flowers, $F(4.71, 301.15) = 1.81$, $p = .12$, $\eta^2p = .027$ (95% CIs [0, 0.059]). Thus, vicarious fear learning was both effective and robust for both marsupials and flowers (see Figures 3a and 3b).

An additional identical analysis was conducted for only those children (marsupials: $n = 21$; flowers: $n = 22$) that had shown fear belief acquisition post-vicarious learning. For this sub-group of children, there was a significant time × pairing type interaction, $F(6, 246) = 4.76$, $p < .001$, $\eta^2p = .10$ (95% CIs [0.027, 0.160]). Planned comparisons showed that compared to post-learning levels ($M = 2.92$, $SD = .93$) fear beliefs for fear-paired animals relative to unpaired animals were not significantly changed at either 1 week ($M = 2.56$, $SD = 1.12$), $F(1, 41) = 3.07$, $p = .087$, $\eta^2p = .07$ (95% CIs [0, 0.245]), or at 2 weeks ($M = 2.36$, $SD = 1.25$), $F(1, 41) = 2.21$, $p = .15$, $\eta^2p = .05$ (95% CIs [0, 0.218]), but were significantly lower at 3 weeks ($M = 2.22$, $SD = 1.24$), $F(1, 41) = 6.77$, $p = .013$, $\eta^2p = .14$ (95% CIs [0.006, 0.332]). For happy-paired animals compared to unpaired animals, fear beliefs were unchanged at 1 week compared to post-learning, ($M = 1.55$, $SD = 1.18$), $F(1, 41) = 2.15$, $p = .15$, $\eta^2p = .05$ (95% CIs [0, 0.216]), but had increased significantly at 2 weeks ($M = 1.54$, $SD = 1.21$), $F(1, 41) = 6.45$, $p = .015$, $\eta^2p = .14$ (95% CIs [0.005, 0.33]) because fear beliefs decreased for unpaired animals. However, fear beliefs decreases at 2 weeks and were no longer significantly higher than post-learning ($M = 1.39$, $SD = 1.10$), $F(1, 41) = 2.58$, $p = .12$, $\eta^2p = .06$ (95% CIs [0, 0.23]). All other interactions for the main ANOVA analysis were nonsignificant, including the time × pairing type interaction × CS group, indicating that

extinction effects were no different for animals or flower, $F(6, 246) = 1.89$, $p = .084$, $\eta^2 p =$

.04 (95% CIs [0, 0.081]).

Avoidance preferences.

Vicarious acquisition. Figures 4a and 4b show mean distances (cm) to the marsupial

and flower stimuli from the figures children placed on the board. A three-way 2(time: pre-

learning vs. post-learning) × 3(pairing type: fear, happy, unpaired) × 2(CS group: marsupials

vs. flowers) mixed ANOVA was performed on NRT scores. Significant vicarious learning

effects were established via a significant time × pairing type interaction, $F(2, 128) = 18.89$, p

$< .001$, $\eta^2 p = .23$ (95% CIs [0.07, 0.385]), showing that vicarious learning led to changes in

avoidance preferences for CSs that were different depending on the type of face presented

with them. Planned comparisons found that there had been a significant increase in

children's avoidance preferences for CSs seen with fear-paired faces, $F(1, 64) = 8.59$, $p =$

$.005$, $\eta^2 p = .12$ (95% CIs [0.119, 0.270]), and a significant decrease in avoidance preferences

for happy-paired stimuli, $F(1, 64) = 11.75$, $p = .001$, $\eta^2 p = .16$ (95% CIs [0.028, 0.311]).

This effect was no different for marsupials and flowers, as evidenced by a nonsignificant time

× pairing type × CS group interaction, $F(2, 128) = 2.35$, $p = .10$, $\eta^2 p = .04$ (95% CIs [0,

0.051]). There was no significant relationship between increases in avoidance preferences

and age or gender.

Fear reduction. A three-way 4(time: post-learning, 1 week extinction, 2 weeks

extinction, 3 weeks extinction) × 3(pairing type: fear, happy, unpaired) × 2(CS group:

marsupials vs. flowers) mixed ANOVA was performed to establish whether extinction

reduced vicariously learned avoidance preferences. The pairing type × time interaction was

significant, which meant that avoidance preferences had changed over time and these changes

were different for stimuli seen together with fearful, happy or no faces. Planned comparisons

showed that, compared to control stimuli, learned avoidance preferences for fear-paired stimuli were significantly lower following the first extinction procedure at 1 week, $F(1, 64) = 19.23$, $p < .001$, $\eta^2 p = .23$ (95% CIs [0.072, 0.388]), and remained lower after the second procedure at 2 weeks, $F(1, 64) = 11.20$, $p = .001$, $\eta^2 p = .15$ (95% CIs [0.025, 0.305]), and the third procedure at 3 weeks, $F(1, 64) = 9.37$, $p = .003$, $\eta^2 p = .13$ (95% CIs [0.016, 0.281]), than they had been post-learning. These effects were mirrored for happy-paired stimuli, which showed an overall increase in fear beliefs at 1 week, $F(1, 64) = 5.61$, $p = .021$, $\eta^2 p = .08$ (95% CIs [0.001, 0.224]), which remained at 2 weeks, $F(1, 64) = 9.87$, $p = .003$, $\eta^2 p = .13$ (95% CIs [0.018, 0.288]), and 3 weeks, $F(1, 64) = 4.35$, $p = .041$, $\eta^2 p = .06$ (95% CIs [0, 0.201]). The time $\times$ pairing type $\times$ CS group interaction was non-significant, $F(6, 384) = 0.49$, $\eta^2 p = .008$ (95% CIs [0, 0.015]), indicating that these post-vicarious learning changes in avoidance preferences due to extinction were no different for marsupial and flower CSs. The effect size was extremely low for this interaction and hence it was highly unlikely that nonsignificance was the result of low power.

An additional analysis examined avoidance preferences just those children (animals: $n = 16$, flowers: $n = 26$) that had shown avoidance learning post-learning. There was a significant time $\times$ pairing type interaction, $F(4.44, 177.75) = 7.27$, $p < .001$, $\eta^2 p = .15$ (95% CIs [0.054, 0.233]), which was followed up with planned comparisons. However, these showed that compared to post-learning levels ($M = 34.76$, $SD = 16.81$) there were no changes in avoidance preferences for fear-paired relative to unpaired stimuli at 1 week ($M = 27.93$, $SD = 17.93$), $F(1, 40) = 0.28$, $p = .60$, $\eta^2 p = .007$ (95% CIs [0, 0.126]), 2 weeks ($M = 27.86$, $SD = 18.18$), $F(1, 40) = 0.88$, $p = .35$, $\eta^2 p = .02$ (95% CIs [0, 0.167]), or 3 weeks ($M = 29.86$, $SD = 30.03$), $F(1, 40) = 0.79$, $p = .38$, $\eta^2 p = .02$ (95% CIs [0, 0.162]). In contrast, happy-paired stimuli showed significantly increased avoidance at each time point compared to post-positive vicarious learning. There was no evidence that these effects were influenced by

stimulus type because the time $\times$ pairing type $\times$ CS group interaction was non-significant, $F(4.44, 177.75) = 0.81$, $p = .53$, $\eta^2 p = .02$ (95% CIs [0, 0.051]). Therefore, vicariously learned avoidance preferences were robust to extinction for both flowers and marsupials when only children showing learned avoidance were included in the analysis.

Experiment 3

Experiment 2 found no evidence that learning was greater for marsupials than flowers. However, despite random assignment, children in the flower group were on average half a year older than children in the marsupial group and older age was associated with greater fear learning overall. Therefore, the possibility remains that learning for flowers was only equal to that for marsupials because children were slightly older in this group.

Experiments 1 and 2 compared speed, magnitude and robustness of vicarious learning for fear-irrelevant flower stimuli and animals for which children in the U.K. would have limited prior learning history. However, although the marsupials were assumed to have greater fear relevance than the flowers, there is no evidence to support this, which limits interpretation of the findings. Stimuli such as snakes are considered to be fear-relevant because a disproportionately high number of individuals fear them compared to other stimuli. Previous research (Askew et al., 2013) compared vicarious fear learning for flowers and marsupials with learning for snakes and found no difference in the magnitude of learned fear responses. But it is not yet known whether the robustness of vicarious learning for marsupials would also be equivalent to classic fear-relevant stimuli such as snakes. Experiment 3 therefore extended the previous two experiments, and the work of Askew et al. (2013), by comparing the robustness of learning for marsupials and snakes after extinction and counterconditioning manipulations. Previous research (Reynolds, Field & Askew, in press) has demonstrated that counterconditioning reduces behavioral and physiological effects of

vicarious fear learning more effectively than extinction in novel marsupials, but the

effectiveness of counterconditioning for fear-relevant stimuli (e.g., snakes) has not yet been

explored.

Method

Participants. Participants were 84 children (46 boys, 38 girls) aged 7-9 years (M =

96.01 months, SD = 7.82 months) recruited from a local school in Hertfordshire, UK. All

had parental consent and gave verbal assent. Children were randomly assigned to the CS-

type group (marsupial or snake) and further assigned to the fear-reduction condition

(extinction or counterconditioning); thus children either received the marsupial CS with

extinction intervention (n = 11 boys and 10 girls), the marsupial CS with counterconditioning

intervention (n = 12 boys and 9 girls), the snake CS with extinction intervention (n = 13 boys

and 8 girls) or the snake CS with counterconditioning intervention (n = 10 boys and 11 girls).

There was no association between gender and group, $\chi^2(3, N = 84) = 0.96$, $p = .81$, and age

was no different across groups, $t(40) = 0.78$, $p = .44$.

Materials. Marsupial and face images as well as FBQ and NRT measures were

identical to Experiments 1 and 2. Three additional color images (346×444 pixels) of three

snakes (keelback, pattoni and boomslang) were used as the fear-relevant CSs; nine in total

(see Askew et al., 2014). These snakes were chosen due to being uncommon in the U.K and

so children were unlikely to have prior experience or knowledge of them. Internal

consistencies for the FBQ were all high (Cronbach's alpha): before vicarious learning, $\alpha = .73$

for the cuscus subscale, .74 for the quokka subscale, .78 for the quoll subscale, .85 for the

boomslang subscale, .81 for the pattoni subscale and .82 for the keelback subscale. Post-

vicarious learning they were .81, .84 and .86 for the marsupials, and .85, .84 and .84 for the

snakes respectively. Post-fear reduction they were .85, .85 and .85 for the marsupials, and

.91, .85 and .87 for the snakes respectively.

Given the likelihood that fear beliefs for snakes might be at the top end of the FBQ

scale, this could lead to problems in detecting an increase in fear cognitions post vicarious-

learning. Therefore, children completed three additional self-report measures of fear (see

Askew et al., 2013) assessing cognitive, behavioral and physiological responding. The self-

reports each involved six graded questions with a 5-point scale calibrated to allow for very

high fear scores. To measure self-reported cognitions, questions began with, "If you knew

there was a room nearby with a [the CS] in a large closed glass box, would you feel scared?",

followed by questions about whether the children would feel scared if they stayed in the room

with the CS in a box, if they touched the glass of the box, if they put their hand in the box but

did not touch the CS, if they put their hand in the box and touched the CS, and finally if they

lifted the CS out of the box. Participants responded on the same 5-point scale used in the

FBQ with higher scores indicating greater fear cognitions. To measure self-reported behavior,

the questions followed the same scenario but children were asked if they would approach in

each situation and then responses were reverse scored so that higher scores indicated greater

behavioral avoidance. Finally, to measure self-reported physiological responses, children

were asked whether their heart would beat faster in each scenario, with higher scores

indicating greater self-reported physiological responses. Internal consistencies (Cronbach's

alpha) for each subscale were all high for each animal at each time point (all between .75 and

.95).

Procedure. The procedure was computerized in a program written in E-Prime 2.0 by

the second author, and presented on a Dell Latitude E6540 laptop with a 15.5" screen.

Children were randomly allocated to one of two groups, marsupials or snakes, and first

completed the FBQ, the questionnaires measuring self-reported cognitions, self-reported behavior and self-reported physiological responses, and finally the NRT (pre learning). The NRT board used in this experiment was slightly longer (45 cm × 68 cm) than that used in Experiments 1 and 2. This was followed by the vicarious learning whereby children received 10 fear-paired trials, 10 happy-paired trials and 10 unpaired trials (30 trials in total). Children then repeated the FBQ, three questionnaire subscales and the NRT (post-learning). They were then subdivided into one of two conditions: counterconditioning or extinction. Children in the counterconditioning group were shown the previously fear-paired marsupial or snake CS images but this time with happy faces. Children in the extinction group were shown the previously fear-paired marsupial or snake CS images again alone, without any accompanying face US. Unlike Experiment 2, extinction trials were not presented for other pairing types (happy-paired and unpaired) in order for the intervention to be more closely matched to the counterconditioning trials. They then completed the FBQ, the self-reported cognitions, self-reported behavior and self-reported physiological responses questionnaires, and then the NRT again for a final time (post-fear reduction). Children were then fully debriefed with games, puzzles and correct information about the snakes or marsupials, depending on the group they were in.

Results

   Fear beliefs.

   Vicarious acquisition. Mean fear belief scores for the fear-paired, happy-paired and unpaired stimuli over time are displayed in Figures 5a (marsupial CS) and 5b (snake CS). FBQ scores were analyzed in a three-way 2(time: pre-learning, post-learning) × 3(pairing type: fear, happy, unpaired) × 2(CS type: marsupials vs. snakes) mixed ANOVA with repeated measures on the first two variables. The main effects of time, $F(1, 82) = 22.51$, $p <$

.001, $\eta^2 p = 0.22$ (95% CIs [0.08, 0.36]) and pairing type, $F(2, 164) = 6.59$, $p = .002$, $\eta^2 p = .07$ (95% CIs [0.12, 0.15]) were significant as well as the more theoretically interesting time × pairing type interaction, $F(2, 164) = 31.69$, $p < .001$, $\eta^2 p = .27$ (95% CIs [0.16, 0.38]), which indicated that vicarious learning led to changes in fear beliefs for CSs depending on the type of faces they were seen with. Planned comparisons indicated a significant increase in fear beliefs for fear-paired CSs, $F(1, 82) = 55.73$, $p < .001$, $\eta^2 p = .41$ (95% CIs [0.24, 0.53]), but not happy-paired CSs, $F(1, 82) = 1.15$, $p = .29$, $\eta^2 p = .01$ (95% CIs [0, 0.10]), compared to unpaired CSs. Fear relevance of the CS (marsupial or snake) had no effect on the magnitude of vicarious learning. This was indicated by a nonsignificant time × pairing type × CS type interaction, $F<1$. The was no significant association between age of children and increases in fear belief. However, increases in fear beliefs were significantly greater for girls ($M = 0.92$, $SD = 0.50$) than boys ($M = 0.49$, $SD = 0.85$), $t(74.98) = 2.86$, $p = .006$, $d = 0.62$.

Fear reduction (all children). A four-way 2(time: post-learning, post-fear reduction) × 3(pairing type: fear, happy, unpaired) × 2(CS type: marsupials vs. snakes) × 2(fear reduction type: counterconditioning vs. extinction) mixed ANOVA was performed on fear belief scores to explore the effect of the fear reduction interventions on reducing vicariously acquired fear beliefs. There were significant main effects of time, $F(1, 80) = 9.62$, $p = .003$, $\eta^2 p = .11$ (95% CIs [0.01, 0.24]) and pairing type, $F(2, 160) = 15.53$, $p < .001$, $\eta^2 p = .16$ (95% CIs [0.07, 0.26]). The four-way time × pairing × CS type × fear reduction interaction was nonsignificant *($F<1$)* indicating no differences in the effectiveness of the fear reduction interventions dependent on CS type. However, there were significant time × pairing × CS type, $F(2, 160) = 4.21$, $p = .02$, $\eta^2 p = .05$ (95% CIs [0, 0.12]) and time × pairing × fear reduction interactions, $F(2, 160) = 7.27$, $p = .001$, $\eta^2 p = .08$ (95% CIs [0.02, 0.17]). Therefore, separate 2(time: post-learning, post-fear reduction) × 3(pairing type: fear, happy,

unpaired) ANOVAs were carried out on fear belief scores for snakes and marsupials

separately (CS type), and extinction and counter-conditioning interventions separately (fear

reduction type).

CS type. Critical time × pairing type interactions were significant in the analyses for

both marsupials, $F(2, 82) = 3.24$, $p = .04$, $\eta^2p = .07$ (95% CIs [0, 0.25]) and snakes, $F(2, 82) =$

13.34, $p < .001$, $\eta^2p = .25$ (95% CIs [0.09, 0.38]). Planned comparisons indicated a significant

decrease in fear beliefs for fear-paired, $F(1, 41) = 5.21$, $p = .028$, $\eta^2p = .11$ (95% CIs [0,

0.30]), and happy-paired marsupials, $F(1, 41) = 6.21$, $p = .020$, $\eta^2p = .13$ (95% CIs [0, 0.32])

compared to unpaired marsupials. However, effects for marsupials would be borderline

significant at best if corrections were made for conducting multiple tests. Comparisons also

showed that there was a significant decrease in fear beliefs for fear-paired snakes compared

to control snakes, $F(1, 41) = 19.50$, $p < .001$, $\eta^2p = .32$ (95% CIs [0.10, 0.50]), but no

significant change ($F < 1$) for happy-paired snakes. Thus, fear reduction was successful for

negatively paired CSs irrespective of CS type. However, this effect was borderline at best in

the case of marsupials and fear reduction effect sizes were much larger for snakes, suggesting

that fear beliefs were reversed more easily for these animals. This result is illustrated by

Figure 5a, which shows that fear beliefs for fear-paired marsupials remained high after

extinction.

Fear reduction type. The time × pairing type interaction, which is important for

testing for increases and decreases in fear beliefs was significant following counter-

conditioning, $F(2, 82) = 16.39$, $p < .001$, $\eta^2p = .29$ (95% CIs [0.12, 0.42]) but not extinction,

$F(2, 82) = 2.45$, $p < .093$, $\eta^2p = .06$ (95% CIs [0, 0.16]). The interaction for counter-

conditioning was followed by further planned comparisons indicating that counter-

conditioning significantly reduced fear beliefs for fear-paired CSs compared to control CSs,

$F(1, 41) = 26.77$, $p < .001$, η^2p $=.40$ (95% CIs [0.16, 0.56]); however, there was no similar difference in fear beliefs for happy-paired CSs compared to the control ($F < 1$). Therefore, the results indicated that, regardless of CS type, only counter-conditioning and not extinction was successful in reducing vicariously acquired fear beliefs. Again, this latter result is illustrated in Figure 5a, which shows (nonsignificant) increases in fear beliefs from post-learning to extinction.

Fear reduction (children showing acquisition only). An identical fear reduction analysis was conducted for only those children (marsupials: $n = 34$; snakes: $n = 36$) that had shown fear belief acquisition post-vicarious learning. This time the four-way time $\times$ pairing type $\times$ CS type $\times$ fear reduction interaction was significant, $F(2, 132) = 4.02$, $p = .02$, η^2p $=.06$ (95% CIs [0, 0.14]) and was followed up with separate 2(time: post-learning, post-fear reduction) $\times$ 3(pairing type: fear, happy, unpaired) mixed ANOVAs for the four CS type/fear reduction groups: marsupial-counterconditioning; marsupial-extinction; snake-counterconditioning; and snake-extinction.

Only the time $\times$ pairing type interaction is of theoretical interest here. For the marsupial-counterconditioning group, this was significant, $F(2, 34) = 5.10$, $p = .012$, η^2p $= .23$ (95% CIs [0.01, 0.42]) with planned comparisons showing that counterconditioning significantly reduced fear beliefs for previously fear-paired marsupials (post-learning: $M = 2.32$, $SD = 0.80$; post-fear reduction: $M = 1.49$, $SD = 0.86$) compared to controls (post-learning: $M = 1.79$, $SD = 0.85$; post-fear reduction: $M = 1.58$, $SD = 0.89$), $F(1, 17) = 10.00$, $p = .006$, η^2p $= .37$ (95% CIs [0.04, 0.60]). The critical interaction was also significant for the marsupial-extinction group, $F(2, 30) = 7.16$, $p = .003$, η^2p $= .32$ (95% CIs [0.05, 0.51]) and there was also a significant reduction in fear beliefs for fear-paired marsupials (post-learning: $M = 2.91$, $SD = 0.63$; post-fear reduction: $M = 2.70$, $SD = 0.81$) compared to controls (post-

learning: $M = 1.47$, $SD = 0.85$; post-fear reduction: $M = 2.15$, $SD = 0.83$), $F(2, 34) = 20.98$, $p < .001$, $\eta^2p = .58$ (95% CIs [0.29, 0.68]). Identical results were found for the snake-counterconditioning group, $F(2, 36) = 25.74$, $p < .001$, $\eta^2p = .59$ (95% CIs [0.34, 0.70]), with follow-ups again showing a reduction in fear beliefs for previously fear-paired snakes (post-learning: $M = 2.59$, $SD = 0.83$; post-fear reduction: $M = 1.54$, $SD = 0.60$) compared to control snakes (post-learning: $M = 1.91$, $SD = 0.93$; post-fear reduction: $M = 1.95$, $SD = 0.92$), $F(1, 18) = 51.99$, $p < .001$, $\eta^2p = .74$ (95% CIs [0.46, 0.84]). However, the crucial interaction was nonsignificant for the snake-extinction group ($F < 1$), suggesting that extinction was not successful for these children. There was no significant difference in fear beliefs for fear paired snakes after extinction (post acquisition: $M = 2.93$, $SD = 0.71$; post-fear reduction: $M = 2.73$, $SD = 0.85$) compared to the unpaired snakes (post acquisition: $M = 2.42$, $SD = 0.82$; post-fear reduction: $M = 2.44$, $SD = 0.98$).

Self-reported fear cognitions.

Vicarious acquisition. A three-way 2(time: pre-learning, post-learning) × 3(pairing type: fear, happy, unpaired) × 2(CS type: marsupials vs. snakes) mixed ANOVA was performed on self-reported fear cognitions. Only effects including time and pairing type are of interest for testing learning predictions. The time × pairing type interaction itself was significant, $F(2, 164) = 6.90$, $p = .001$, $\eta^2p = .08$ (95% CIs [0.01, 0.16]) with planned comparisons indicating that self-reported cognitions for fear-paired stimuli significantly increased from baseline ($M = 1.72$, $SD = 0.93$) to post-vicarious learning ($M = 2.08$, $SD = 0.94$) compared to unpaired stimuli (pre-learning: $M = 1.95$, $SD = 1.05$; post-learning: $M = 1.88$. $SD = 1.04$), $F(1, 82) = 12.13$, $p < .001$, $\eta^2p = .13$ (95% CIs [0.02, 0.27]). There was no similar significant change for stimuli seen with happy faces compared to unpaired stimuli ($F < 1$). The time × pairing type × CS type interaction was nonsignificant ($F < 1$). Thus findings showed that vicarious learning increased fear cognitions similarly for both types of stimuli.

Further analysis indicated that there was no significant relationship between increases in self-reported fear cognitions and age or gender.

Fear reduction. A four-way 2(time: post-learning, post-fear reduction) × 3(pairing type: fear, happy, unpaired) × 2(CS type: marsupials vs. snakes) × 2(fear reduction type: counterconditioning vs extinction) mixed ANOVA demonstrated a significant main effect of pairing, $F(2, 160) = 3.78$, $p = .03$, $\eta^2p = .05$ (95% CIs [0, 0.11]); however, all effects including a time × pairing type interaction were nonsignificant, indicating that fear cognitions were not reduced following the fear reduction phase. An additional identical analysis looked at fear reduction in only children showing acquisition of self-reported cognitions post-vicarious learning (marsupials: $n = 25$; snakes: $n = 27$), but all interactions including time and pairing type were nonsignificant, again indicating no reduction in fear cognitions.

Self-reported behavioral avoidance.

Vicarious acquisition. An identical set of analyses was also performed on self-reported behavior ratings, indicating a significant time × pairing type × CS type interaction, $F(2, 164) = 3.78$, $p = .025$, $\eta^2p = .04$ (95% CIs [0, 0.11]). In order to follow-up this interaction, separate 2(time: post-learning, post-fear reduction) × 3(pairing type: fear, happy, unpaired) ANOVAs were conducted on behavioral ratings for snakes and marsupials separately (CS type). The time × pairing type interaction was nonsignificant ($F < 1$) for marsupials, but significant for snakes, $F(2, 82) = 8.97$, $p < .001$, $\eta^2p = .18$ (95% CIs [0.04, 0.31]). Reported avoidance did not significantly change for fear-paired marsupials (pre-learning: $M = 1.62$, $SD = 0.82$; post-learning: $M = 1.69$, $SD = 0.85$) compared to unpaired marsupials (pre-learning: $M = 1.64$, $SD = 0.88$; post-learning: $M = 1.77$, $SD = 0.99$). In contrast, planned follow-up tests for snakes revealed a significant increase in avoidance for the fear-paired snake (pre-learning: $M = 1.88$, $SD = 1.01$; post-learning: $M = 2.36$, $SD = 0.95$)

compared to the unpaired snake (pre-learning: $M = 2.18$, $SD = 1.07$; post-learning: $M = 2.04$, $SD = 1.10$), $F(1, 41) = 22.01$, $p < .001$, $\eta^2p = .35$ (95% CIs [0.12, 0.52]), but no significant change for snakes seen with happy faces (pre-learning: $M = 2.11$, $SD = 1.04$; post-learning: $M = 2.19$, $SD = 1.08$) compared to control snakes, $F(1, 41) = 1.95$, $p = .17$, $\eta^2p = .05$ (95% CIs [0, 0.21]). Additional analyses found no significant association between increases in self-reported behavioural avoidance and age or gender

Fear reduction. All effects including the time × pairing type interaction were nonsignificant, suggesting that there was no reduction in self-reported avoidance (all $p > .18$ except for time × pairing type × fear reduction type interaction: $p = .084$). However, given that not all children showed acquisition of self-reported behavioral avoidance post-vicarious learning, it was important to investigate only those that did in a separate analysis. An identical analysis was conducted with these children (marsupials: $n = 23$; snakes: $n = 31$) and the time × pairing type × fear reduction type interaction was the only significant interaction effect, $F(2, 100) = 3.31$, $p = .04$, $\eta^2p = .06$ (95% CIs [0, 0.16]). It was followed-up with two separate time × pairing type ANOVAs for extinction and counter-conditioning interventions separately. Even when accounting for a reduction in the alpha value due to conducting several tests, the critical time × pairing type interaction was significant for the counterconditioning group, $F(2, 52) = 7.18$, $p = .002$, $\eta^2p = .22$ (95% CIs [0.04, 0.38]), but not for the extinction group ($F < 1$). Planned comparisons showed that counterconditioning led to a significant decrease in self-reported avoidance behavior for previously fear-paired stimuli (post-learning: $M = 2.02$, $SD = 0.96$; post-fear reduction: $M = 2.13$, $SD = 1.00$) compared to control stimuli (post-learning: $M = 1.90$, $SD = 1.05$; post-fear reduction: $M = 1.90$, $SD = 1.06$), $F(1, 26) = 11.63$, $p = .002$, $\eta^2p = .31$ (95% CIs [0.05, 0.52]). Therefore, the results suggested that counterconditioning led to fear reduction but CS-alone extinction had

no effect. This effect was the same for all stimuli; there was no difference between children in the marsupial and snake groups.

Self-reported physiological responses.

Vicarious acquisition. A significant time × pairing interaction, $F(2, 164) = 42.56$, $p < .001$, $\eta^2 p = .34$ (95% CIs [0.22, 0.44]) was followed by planned comparisons showing a significant increase in self-reported physiological responses for fear-paired CSs (pre-learning: $M = 1.78$, $SD = 0.94$; post-learning: $M = 2.63$, $SD = 0.89$) compared to unpaired CSs (pre-learning: $M = 1.87$, $SD = 0.98$; post-learning: $M = 1.80$, $SD = 0.98$), $F(1, 82) = 73.15$, $p < .001$, $\eta^2 p = .47$ (95% CIs [0.31, 0.59]). There were no equivalent significant changes for stimuli seen with happy faces (pre-learning: $M = 1.87$, $SD = 0.96$; post-learning: $M = 1.90$, $SD = 1.00$) compared to unpaired stimuli ($F < 1$). In addition, the time × pairing × CS type interaction was nonsignificant ($F < 1$), so acquisition was no different for marsupials and snakes. Additional analyses indicated there was no significant relationship between increases in self-reported physiological responses and age or gender.

Fear reduction. There were significant time × pairing type, $F(2, 160) = 11.64$, $p < .001$, $\eta^2 p = .13$ (95% CIs [0.04, 0.22]) and time × pairing type × fear reduction type interactions, $F(42, 160) = 4.74$ $p = .010$, $\eta^2 p = .06$ (95% CIs [0.32, 0.50]), showing that fear reduction was successful and different for counterconditioning and extinction groups. In order to understand this effect better, 2(time: post-learning, post-fear reduction) × 3(pairing type: fear, happy, unpaired) ANOVAs investigated self-reported physiological ratings in the counterconditioning and extinction groups separately. In the counterconditioning group, the time × pairing type interaction was significant, $F(2, 82) = 19.53$, $p < .001$, $\eta^2 p = .32$ (95% CIs [0.16, 0.45]) with planned comparisons indicating a significant decrease in self-reported physiological responses for fear-paired (post-learning: $M = 2.35$, $SD = 0.98$; post-fear reduction: $M = 1.65$, $SD = 0.99$) compared to unpaired stimuli (post-learning: $M = 1.72$, SD

= 1.03; post-fear reduction: $M = 1.73$, $SD = 1.12$), $F(1, 41) = 21.47$, $p < .001$, $\eta^2p = .40$ (95% CIs [0.12, 0.52]). For the extinction group, the time × pairing type interaction was nonsignificant ($F < 1$). Therefore, counterconditioning of self-reported physiological responses was successful, but extinction was not.

The analysis was run again with only those children (marsupials: $n = 35$; snakes: $n = 37$) that had shown increases in physiological ratings after vicarious fear learning. Only the time × pairing type, $F(2, 136) = 17.82$, $p < .001$, $\eta^2p = .21$ (95% CIs [0.09, 0.31]) and time × pairing type × fear reduction type, $F(2, 136) = 4.63$, $p = .01$, $\eta^2p = .06$ (95% CIs [0, 0.15]), interactions were significant. Follow-up ANOVAs found that the time × pairing type interaction was significant for the counterconditioning group, $F(2, 72) = 24.30$, $p < .001$, $\eta^2p = .40$ (95% CIs [0.22, 0.53]) even accounting for multiple tests, but not for the extinction group, $F(2, 68) = 1.87$, $p = .162$, $\eta^2p = .05$ (95% CIs [0, 0.16]). Planned comparisons showed that counterconditioning led to a significant reduction in self-reported physiological responses for fear-paired stimuli (post-learning: $M = 2.45$, $SD = 0.94$; post-fear reduction: $M = 1.66$, $SD = 0.98$) compared to unpaired stimuli (post-learning: $M = 1.73$, $SD = 1.02$; post-fear reduction: $M = 1.73$, $SD = 1.10$), $F(1, 36) = 29.21$, $p < .001$, $\eta^2p = .45$ (95% CIs [0, 0.16]). Thus, as for behavioral avoidance, counterconditioning was successful but extinction was not.

Avoidance preferences (NRT).

Vicarious acquisition. Mean distances to fear-paired, happy-paired and unpaired stimuli on the nature reserve task are displayed in Figures 6a (marsupial) and 6b (snakes). As for other measures, three-way mixed ANOVA was performed on NRT scores. The Greenhouse-Geisser adjusted time × pairing type interaction, $F(1.77, 144.82) = 27.53$, $p < .001$, $\eta^2p = .25$, (95% CIs [0.13, 0.36]) and time × pairing type × CS type interaction, $F(1.77, 144.83) = 11.57$, $p < .001$, $\eta^2p = .12$, (95% CIs [0.04, 0.24]) were significant. To follow up

the significant three-way interaction, separate time × pairing type analyses were conducted on the CS type separately. For marsupials, the important time × pairing type interaction, $F(2, 82)$ = 42.84, $p < .001$, η^2p = .51 (95% CIs [0.35, 0.61]), was significant. Comparisons revealed that avoidance preferences for fear-paired marsupials increased from baseline to post-vicarious fear learning compared to unpaired marsupials, $F(1, 41)$ = 56.86, $p < .001$, η^2p = .58 (95% CIs [0.36, 0.70]); however, there was no significant change in avoidance preferences for happy-paired marsupials compared to unpaired marsupials, $F(1, 41)$ = 1.78, p = .19, η^2p = .04 (95% CIs [0, 0.20]). For snakes, the crucial time × pairing type interaction was not significant, $F(2, 82)$ = 2.37, p = .10, η^2p = .06 (95% CIs [0, 0.16]), indicating no increase in avoidance preferences overall. Further analysis found no significant association between avoidance preferences increases and age or gender.

Fear reduction. Given that there were no overall increases in avoidance preferences for snakes, the analysis was conducted only on children that had shown acquisition of avoidance preference due to vicarious learning (marsupials: n = 32; snakes: n = 17). A significant time × pairing type interaction was found, $F(2, 90)$ = 9.30, $p < .001$, η^2p = .17 (95% CIs [0.04, 0.30]) with all other interactions nonsignificant. Planned comparisons indicated a significant decrease in avoidance preferences for the fear-paired animal compared to the unpaired animal $F(1, 45)$ = 15.53, $p < .001$, η^2p = .26 (95% CIs [0.06, 0.44]) but no significant change in avoidance preferences for the happy-paired animal compared to the unpaired animal, $F(1, 45)$ = 1.11, p = .30, η^2p = .02 (95% CIs [0, 0.16]). The interaction with CS-type was non-significant, $F(2, 90)$ = 1.97, p = .15, η^2p = .04 (95% CIs [0, 0.13], as was the interaction involving fear reduction type, suggesting that avoidance reduction was no different for marsupials and snakes. Given the small effect size, this is unlikely to be a power issue due to the reduced sample size.

Discussion

Selective associations for fear-relevant stimuli are typically evidenced in the laboratory by speedier, greater, and more robust learned fear responses. Three experiments examined the speed, magnitude, and robustness of vicarious fear learning in children for novel stimuli with differing levels of fear relevance. In Experiment 1, the number of CS-US trials was manipulated (1, 10, or 30 trials) in pairings of marsupials and flowers (CSs) with emotional faces (USs) to determine whether acquisition would be more rapid (i.e., in fewer trials) for stimuli of greater fear relevance (in this case marsupials). Follow-up measures were conducted at 1 week to determine whether fear learning was more robust for one type of CS, or set of trials, than another. Experiment 2 investigated robustness of learning for the two types of stimuli after three extinction trials over a period of 3 weeks. Experiment 3 again explored the magnitude and robustness of learning to extinction and counterconditioning procedures for the marsupials, this time compared to snakes, an established fear-relevant stimulus set.

Results showed that: (a) there was no difference in the speed of fear-related learning for marsupials and flowers in terms of number of trials to achieve learning (Experiment 1); (b) learning can occur for marsupials and flowers during a single trial (Experiment 1); (c) the magnitude of vicariously acquired fear responses was not generally found to be greater for snakes than marsupials, nor was it generally greater for marsupials than for flowers (Experiments 1, 2 and 3); and (d) there was little evidence of either vicariously learned fear of snakes being more robust then vicariously learned fear of marsupials, or learned fear of marsupials being more robust than vicariously learned fear of flowers (Experiments 1, 2 and 3).

Overall, the findings supported previous research showing that vicarious fear learning leads to increases in children's fear beliefs and avoidance preferences (e.g., Askew & Field,

2007; Askew et al., 2008; 2014; Dunne & Askew, 2013, 2016; Reynolds et al., 2014). No difference in the magnitude of 15- to 20-month-old's vicariously learned fear and avoidance for fear-relevant stimuli (snakes and spiders) compared to fear-irrelevant stimuli (flowers and mushrooms) was found by Dubi et al. (2008). Similarly, Askew et al. (2013) found that vicariously acquired increases in 6 to 10-year-old's fear beliefs and avoidance preferences were similar for a range of fear-relevant and fear-irrelevant stimuli including flowers, snakes, caterpillars and the marsupials used here. These findings were confirmed in the current study: Although marsupials were assumed here to have higher fear relevance than flowers in Experiments 1 and 2, no enhanced learning was observed in terms of magnitude of vicariously learned fear-related responses for marsupials. Likewise, the magnitude of vicariously learned fear responses was generally no greater for snakes (a traditional fear-relevant stimulus) than for marsupials in Experiment 3. This was the case for fear beliefs, self-reported fear cognitions, and self-reported physiological responses. The two behavior-related measures produced more contradictory evidence. Learning of self-reported behavioral avoidance was observed for snakes but not marsupials; however, the reverse was found for avoidance preferences in the nature reserve task: learning was observed for marsupials but not snakes. The explanation for these findings is not clear. It is possible that avoidance preferences tap into a more behavioral dimension of the fear avoidance response, whereas self-reported behavioral avoidance taps into pre-behavior cognitions. However, this does not explain the current findings unless, for example, behavioral fear of marsupials is less conscious than for snakes, which does not appear likely. Especially given that Figure 6b suggests that only the snake extinction group, not the snake counterconditioning group, shows lack of avoidance preference learning.

Two new findings were that higher fear relevance does not necessarily produce faster or more robust fear learning in children: vicariously learned increases in fear beliefs and avoidance preferences were acquired in the same number of trials for marsupials and flowers

in Experiment 1; varying the number of trials between 1, 10, and 30 did not make a

difference to fear-learning for either stimulus type. These results demonstrate that vicarious

learning of fear beliefs and avoidance preferences can occur for both marsupials and flowers

in just one CS-US trial in 6- to 10-year-olds, and exposure to more trials does not appear to

increase the magnitude of learning compared to one-trial learning. To the authors'

knowledge, this is the first time this single vicarious leaning trial effect has been

demonstrated in children of this age. However, it makes sense from a survival perspective

that young children would be hardwired to learn which stimuli are threatening by observing

adults during a single learning event.

Robustness of learned fear beliefs and avoidance preferences over a 1 week period was

also identical for both types of stimuli in Experiment 1, regardless of fear relevance, and was

not affected by number of learning trials children had seen. Likewise, children's learned fear

beliefs and avoidance preferences for both CSs showed similar resistance to extinction in

Experiment 2. Avoidance preferences were resistant to extinction for 1 week for both CS

types. When only responses of children that had shown acquisition were analyzed, learned

avoidance was robust for the full 3 weeks and fear beliefs for 2 weeks for both animals and

flowers. Similarly, Experiment 3 demonstrated that fear beliefs and self-reported cognitions,

behavior, and physiological responses were similarly resistant to extinction for marsupials and

snakes. This was also the case when only responses of children that had shown acquisition

were analyzed, except for fear beliefs which did show some evidence of extinction for

marsupials, but not snakes, here. In part, the results support previous research (Dunne &

Askew, 2013, 2016; Reynolds et al., in press) demonstrating vicarious counterconditioning as

an effective means of reducing vicariously acquired fear beliefs, avoidance preferences and

self-reported physiological and behavioral responses for marsupials and snakes. However, these

results were not supported by one of the measures, with self-reported fear cognitions showing

robustness to counterconditioning. What was very clear was that there was no measure for which vicariously learned fear responses for snakes were more robust than for marsupials during counterconditioning, there was never any difference in robustness for the two sets of stimuli.

These findings appear to be inconsistent with preparedness theory and evidence from direct fear conditioning experiments with adults (e.g., Öhman & Mineka, 2001; but see also McNally, 1987, 2016), and vicarious learning studies with monkeys (Cook & Mineka, 1989, 1990) and adults (Hygge & Öhman, 1978), which have demonstrated superior learning for fear-relevant stimuli. Both direct conditioning (Öhman et al., 1976; Öhman & Dimberg, 1978) and vicarious learning (Hygge & Öhman, 1978) studies with adults, for example, have found significantly greater resistance to extinction for fear-relevant stimuli compared with fear-irrelevant stimuli. This was only found once for one measure here: Fear beliefs in Experiment 3 were extinguished for marsupials but not snakes when only children showing acquisition were analyzed, offering some support for preparedness. But this would seem to be outweighed by evidence from other measures. Of course, nonsignificant differences between groups such as those reported often need to be interpreted with caution because they could merely be the result of lack of power. However, given that sample sizes were good (140, 66 and 84 children in the three experiments respectively), p-values were high, and effect sizes for key interactions with CS type were close to zero, and therefore trivial, there is no evidence to support a power explanation for the lack of differences between stimuli.

Explanations for the findings may be related to the types of stimuli used, or the way they are presented. In regard to presentation, an explanation for why snakes did not show superior vicarious learning in Experiment 3 could be that still pictures of snakes may not be as fear relevant as film of snakes. Evidence for this comes from a study by DeLoache and LoBue

(2009) showing selectivity to associate moving but not still images of snakes with fear. Thus movement may be important to snake fear relevance and future research in this area should use films of snakes and marsupials to test this theory. In Experiments 1 and 2 stimulus type may have been more critical to findings. Öhman and Mineka (2001; Mineka & Öhman, 2002) have argued for a two levels of learning model of human fear conditioning in which factors such as CS characteristics, US intensity, and controllability of the US influence whether 'cognitive' (mediated by the hippocampus) or 'emotional' (mediated by the amygdala) fear learning occur. Fear-irrelevant CSs only produce the cognitive type of learning, but phylogenetic fear-relevant stimuli produce both types of learning simultaneously and activate an evolutionarily shaped behavioral system they call the 'fear module', which has a specific set of characteristics including those seen in selective associations. If we accept this theory, one possibility is that marsupial CSs used here were not fear-relevant enough to trigger the fear module and produce selective associations. This scenario essentially assumes that fear relevance is a discrete categorisation, rather than an attribute on a continuous scale as assumed in Experiments 1 and 2. However, the objective determination of fear relevance is problematic because of the circular nature of any definition, which relies on the demonstration of superior conditioning in the laboratory. It is impossible to experimentally demonstrate in the laboratory that a novel stimulus is fear-relevant but does not show selective associations because a stimulus is assumed to be fear-relevant when selective associations are observed. If superior learning is not observed for a stimulus, it would likely be classified as fear-irrelevant. Öhman and Mineka's model also predicts that fear-irrelevant CSs lead to a cognitive but not emotional style of learning. However, there is also evidence that vicarious learning can lead to increases not only in children's fear beliefs but also avoidance preferences, behavioural avoidance, heart rate, and attentional bias for the marsupials used here (Askew & Field, 2007; Askew, et al., 2008, 2014; Dunne & Askew,

2013; Reynolds et al., 2014). Thus learning for these stimuli has been demonstrated in all three of Lang's (1968) fear-response systems and is not merely at the cognitive level, suggesting some degree of fear relevance via this definition.

Stimuli are typically labelled as fear-relevant if a disproportionately high number of individuals fear them compared to other stimuli. The animals used in Experiments 1 and 2 are relatively uncommon compared to for example snakes and spiders, and the lack of any information about their fear relevance might be argued to limit interpretation of these findings. Traditional fear-relevant stimuli such as snakes and spiders may already likely be very familiar to children in this age group (though not to Dubi et al.'s, 2008, toddlers, who also found no difference in learning for snakes and spiders) and a central aim of Experiments 1 and 2 was to use uncommon CSs for which U.K. children would not have a learning history or existing set of threat-related beliefs. When Askew et al. (2013) did compare learning for flowers and marsupials with learning for snakes they found no difference in the magnitude of learned fear responses. Extending this, when snakes were used here in Experiment 3 there was no evidence of superior learning and very little evidence of superior resistance to fear reduction compared to marsupials.

There was little difference then between marsupials and flowers in terms of magnitude, speed and robustness of learning and snakes and marsupials in terms of magnitude and robustness of learning. But this did not appear to be because all stimuli essentially acted like fear-irrelevant stimuli: Learning for both flowers and marsupials occurred in one-trial, and was robust to extinction, which is more akin to what we would expect for fear-relevant stimuli. Askew et al. (2013) have suggested that stimulus fear relevance might be bypassed during vicarious learning in young children. The current findings appear to support this in that CS fear relevance appeared unimportant for the

vicarious formation of CS-US associations. One explanation for this could be that childhood is a time when a lot of new information is learned but for our ancestors was likely to also have been a period of particular vulnerability to environmental threats. In terms of survival it may have been advantageous for young children to rapidly learn robust threat beliefs and avoidance from more experienced adults for all types of stimuli. That is, during childhood, when individuals are at their most vulnerable, it is better to be safe than sorry. More selectivity in learning may develop later when individuals have more experience of stimuli in their environment and can distinguish between different levels of danger. In this scenario, typical laboratory demonstrations of selective associations in adults might be due either to biological preparedness or participants' previous experience of a stimulus and their beliefs about its association with threat. Davey (1992, 1995, 1997) has suggested, for example, that selective associations can be explained by expectancies about the negative outcome (US) of a learning event involving a particular CS. Children in the current study would be unlikely to have existing beliefs about the likely association of the unfamiliar stimuli with threat, so expectancies and therefore learning would have been similar for both stimuli. However, the increased resistance to extinction exhibited by the flowers here might be explained by children's previous learning history. If they have learned, for example, that plants can sometimes be poisonous or cause pain this might affect learning for novel plants.

There were some differences in results obtained for extinction and counterconditioning in Experiment 3, with counterconditioning showing evidence of more success than extinction on some measures. This supports similar findings by Reynolds et al., in press). When Dunne and Askew (2013, 2016) used an identical vicarious counterconditioning procedure, children's fear-related responses returned to baseline levels. Inhibitory learning processes are argued to underpin extinction in which the original CS-US association competes with a CS-'no US' association (see e.g., Bouton, 1993, 2002). Thus,

rather than erasing the existing CS-US association from memory, extinction involves the

learning of new, CS-'no US', associations, which compete with previously learned CS-US

associations. If counterconditioning is positive US learning and extinction is 'no US' learning

it is not unreasonable to predict that the former may be a more potent means for reducing fear-

related responses. One notable difference between the two procedures here is that extinction

was not a vicarious procedure in that it did not involve a model's response (US). Fear

reduction may be more successful when the learning and 'unlearning' pathways match (Öst,

1985), so vicarious counterconditioning may be a better way to reduce vicariously acquired

fears than a direct fear reduction method. Some indirect support for this comes from a study by

Kelly, Barker, Field, Wilson, and Reynolds (2009) who found positive information superior to

positive modelling for reducing informationally acquired fear responses. However, recent

evidence suggests that vicarious counterconditioning and positive verbal information are both

effective ways to reverse vicariously learned fear responses (Reynold, Dunne, Wasely, &

Askew, 2016). An alternative explanation for the lack of extinction in Experiment 3 is simply

that not enough trials were used; this is supported by Experiment 2 in which extinction was

more successful when a higher number of extinction trials were used over several weeks.

Experiment 3 demonstrated that vicarious learning did not significantly increase

avoidance preferences for snakes, despite evidence of vicariously acquired fear of snakes as

measured by fear beliefs and all other self-report measures. One difference between the

measures may be that the NRT is a more direct behavioral measure of children's fear of

stimuli than the FBQ, which presumably taps into children's cognitions. Measures of fear

cognitions, avoidance, and physiological changes do not always correlate (Hodgson &

Rachman, 1974; Lang, Melamed, & Hart, 1970; Rachman & Hodgson, 1974; Zinbarg, 1998)

and the NRT may be a more direct and instinctive measure of how children would actually

respond to the stimuli than the FBQ. Related to this may be the finding that vicariously

learned fear beliefs for snakes were more resistant to an extinction manipulation than fear

beliefs for marsupials. On all other self-report measures and avoidance preferences

robustness to extinction and counterconditioning appeared to be the same for both stimuli.

The vicarious learning paradigm used here has demonstrated changes in children

behavioral avoidance (e.g., Askew & Field, 2007) and physiological responses (heart rate;

e.g., Reynolds et al., 2014). However, one possible constraint on the current findings is that,

apart from the NRT measure of avoidance, self-report measures were exclusively relied on.

Future work should extend the procedure to look at changes in heart rate or galvanic skin

responses. It remains a possibility that differential fear learning and reduction not detected

here would be observed on these measures. Another potential limitation of the procedure is

that the vicarious counterconditioning and extinction procedures are unlikely to be as potent

as in clinical practice where for example graduated exposure therapy can be successful in a

single session (e.g., Öst, 1996). A further possible limitation of the current study was that

although magnitude and robustness of vicariously learned fear was investigated for flowers,

marsupials, and snakes, speed of learning was only examined for flowers and marsupials. In

theory, it remains possible that vicarious fear learning is speedier for snakes; however, given

that learning already occurred in just one trial for both animals and flowers here, any speedier

learning for snakes would necessarily be so small as to be undetectable using the current

paradigm. An alternative interpretation of the findings might be that they do not result from

vicarious learning but rather from direct conditioning. That is, the scared face stimuli may be

directly eliciting fear responses in children that are then associated with the CS images.

However, there is little support for this view. When Askew and Field (2007) asked children

about their response to the fear faces use in their experiment they reported that although the

faces appeared to be significantly scared, looking at them did not make them feel

significantly scared. This suggests that faces have an indirect, rather than direct, learning effect.

Summary

Selective associations for fear-relevant CSs are characterised by larger fear responses, rapid fear learning, and more robust learned fear (see e.g., Öhman & Mineka, 2001). Three experiments found no difference in vicarious learning for three stimuli of differing fear relevance: flowers (lower fear relevance), novel marsupials (higher fear relevance) and snakes (traditional fear-relevant). Learned fear responses for marsupials were not found to be larger, faster, or more persistent than for flowers in Experiments 1 and 2. Furthermore, Experiment 3 indicated vicariously learned avoidance preferences and self-reported fear cognitions and behavioral responses for snakes were no greater or robust than for marsupials. Only learning of self-reported behavioral avoidance was greater for snakes than marsupials but avoidance preferences measured using the NRT showed the opposite effect, with learning for marsupials but not snakes. Fear beliefs for snakes showed more resistance to extinction than for marsupials, though no differences were found on any of the other measures for extinction or counterconditioning. One possibility is that fear relevance is less important for children in this age group than for adults because it is advantageous in terms of survival to avoid all stimuli in the environment indicated as threatening by more experienced adults. More selective learning may develop or become more important later, or may be the result of socialization and information individuals receive over time.

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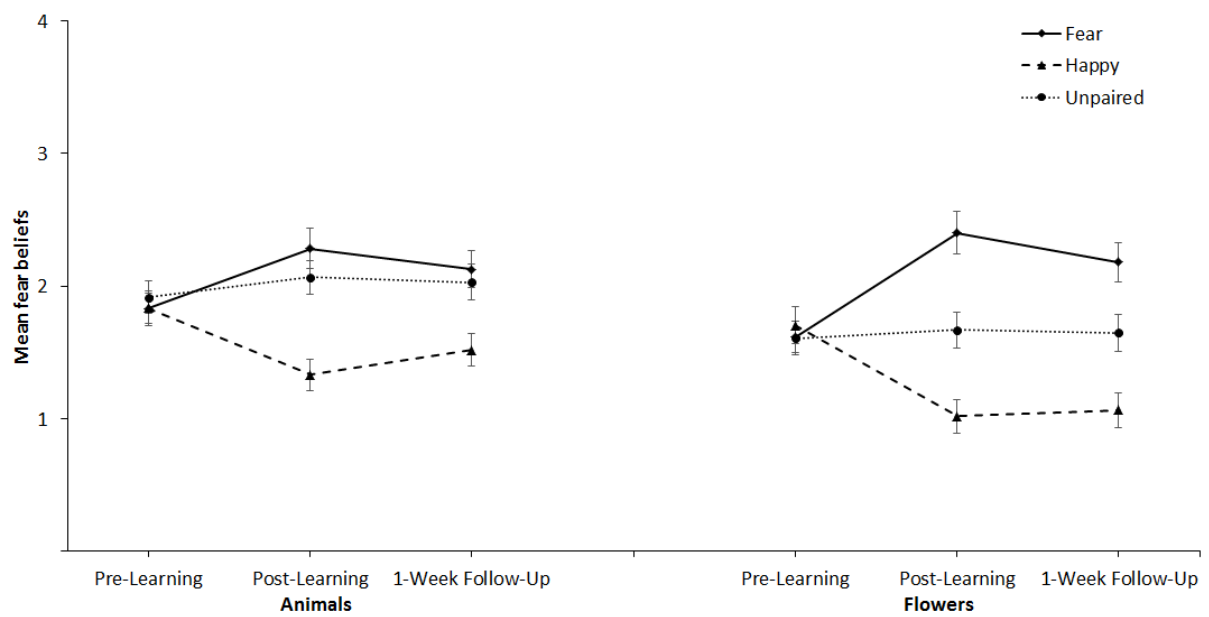
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Figure 1. Mean fear beliefs (and SE) for fear-paired, happy-paired, and unpaired (control) marsupials and flowers CSs pre-learning, post-learning, and after 1 week in Experiment 1.
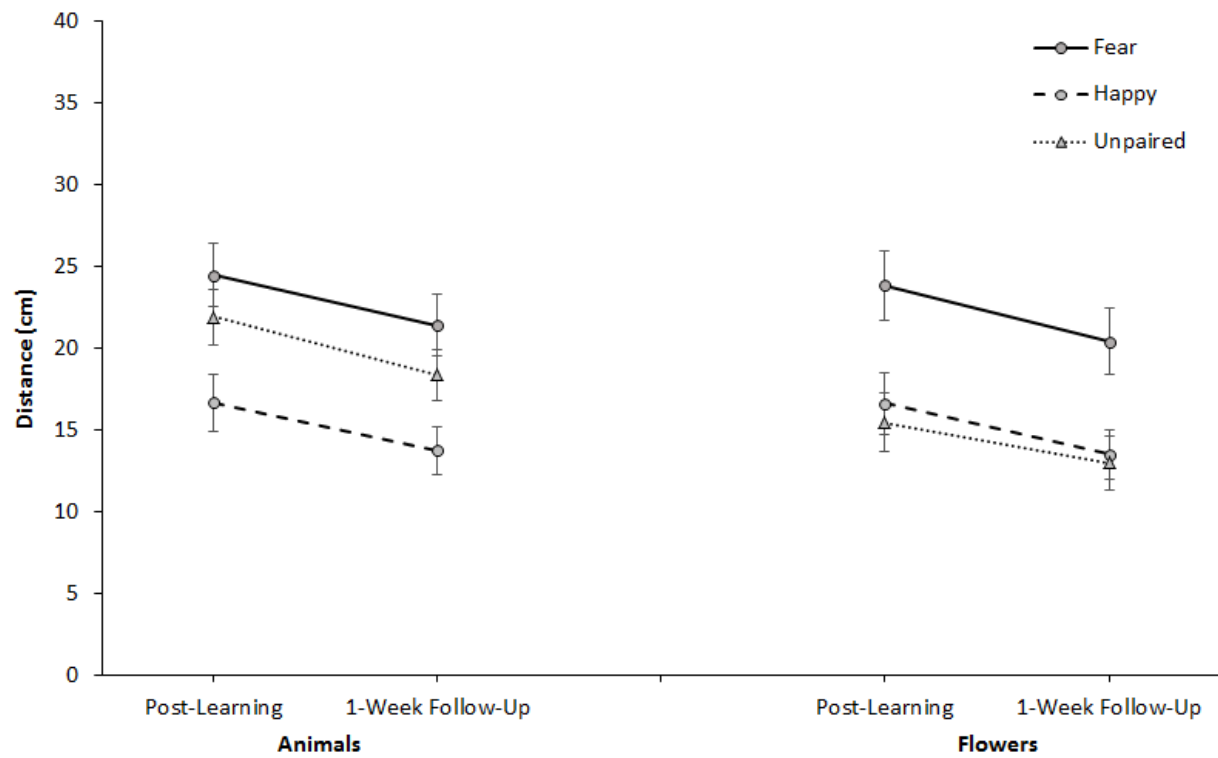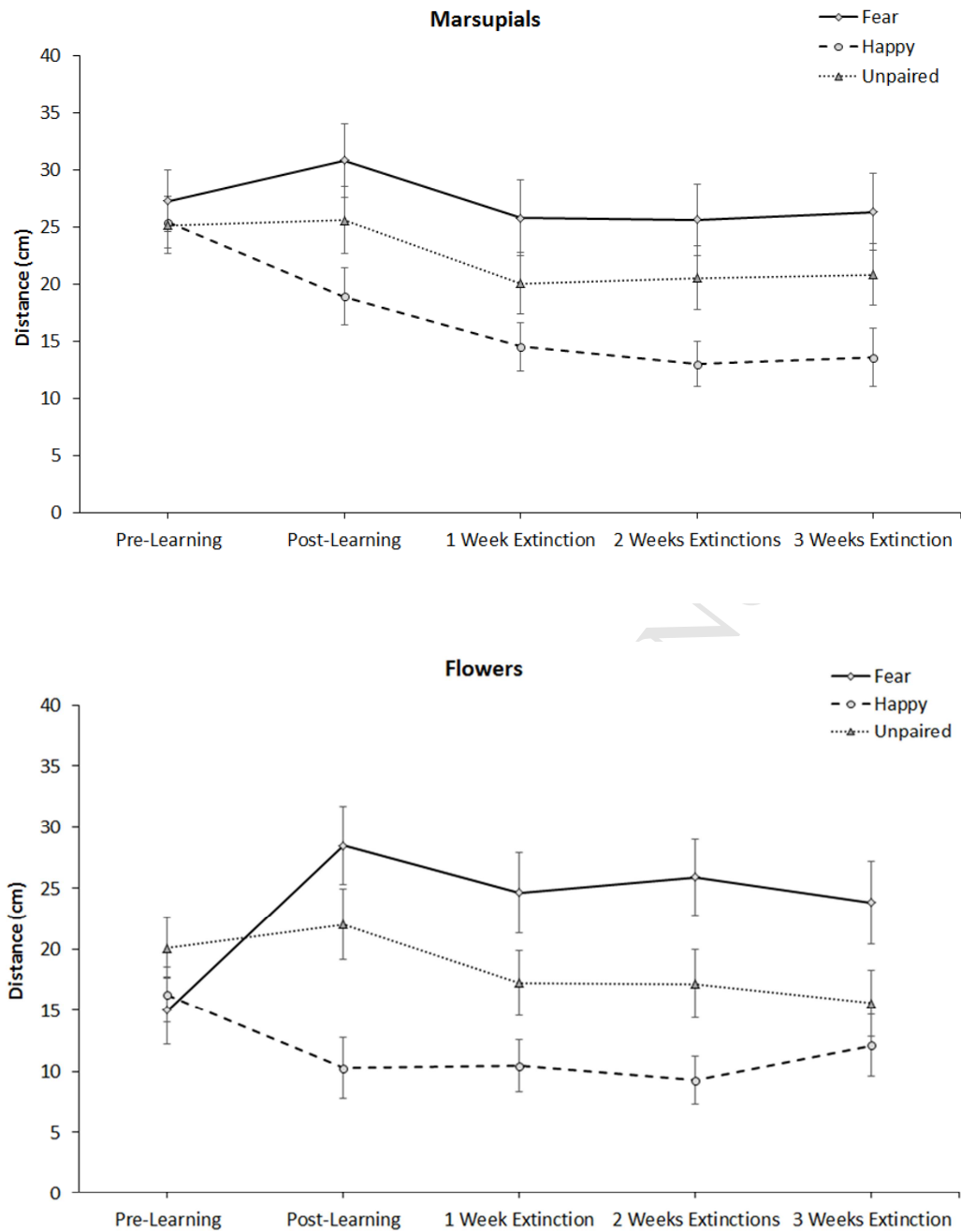
Figure 2. Graph showing mean (and SE) avoidance preferences for marsupials and flowers in the nature reserve task post-learning and at 1 week in Experiment 1
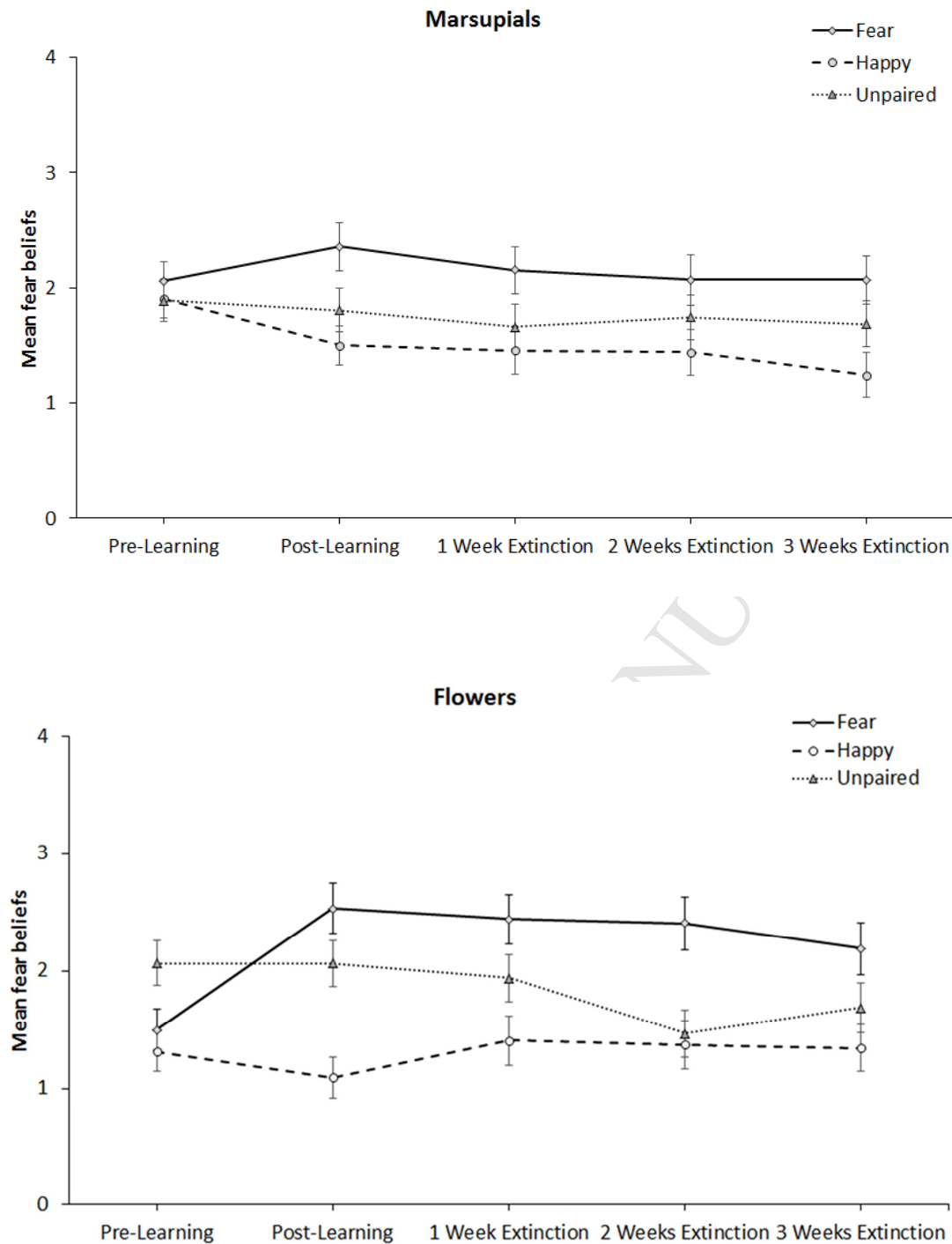
Figures 3a and 3b. Mean fear beliefs for fear-paired, happy-paired, and unpaired (control) marsupials and flowers pre- and post-vicarious learning, and following extinction at 1, 2, and 3 weeks (Experiment 2).

Figures 4a and 4b. Children's mean (and SE) avoidance preferences for marsupials and flowers in the nature reserve task pre- and post-vicarious learning and following extinction at 1, 2 and 3 weeks (Experiment 2).
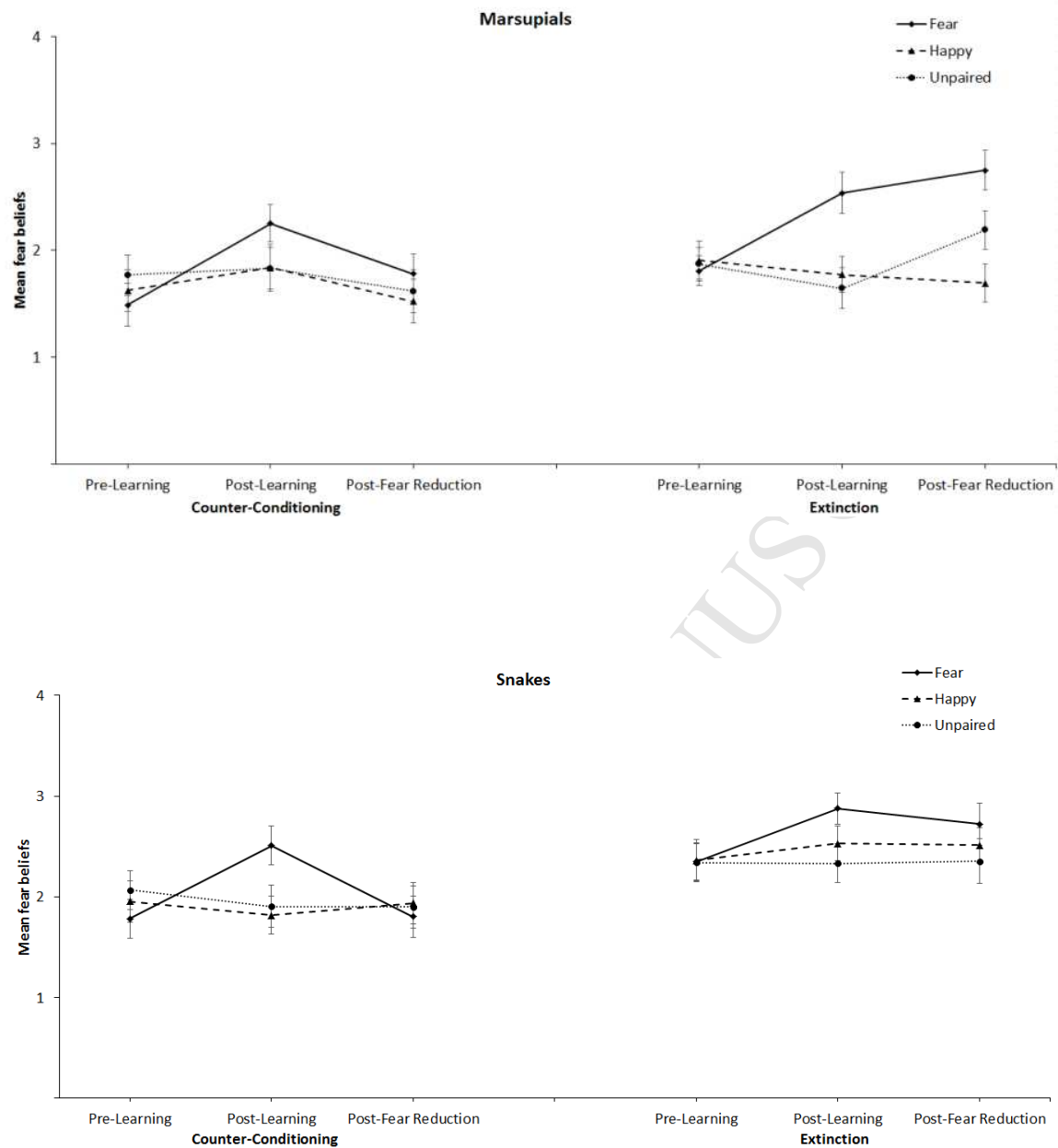
Figures 5a and 5b. Mean fear beliefs (and SE) for fear-paired, happy-paired, and unpaired (control) marsupial and snake CSs, pre-learning, post-learning, and post-fear reduction for the counterconditioning and extinction groups (Experiment 3).
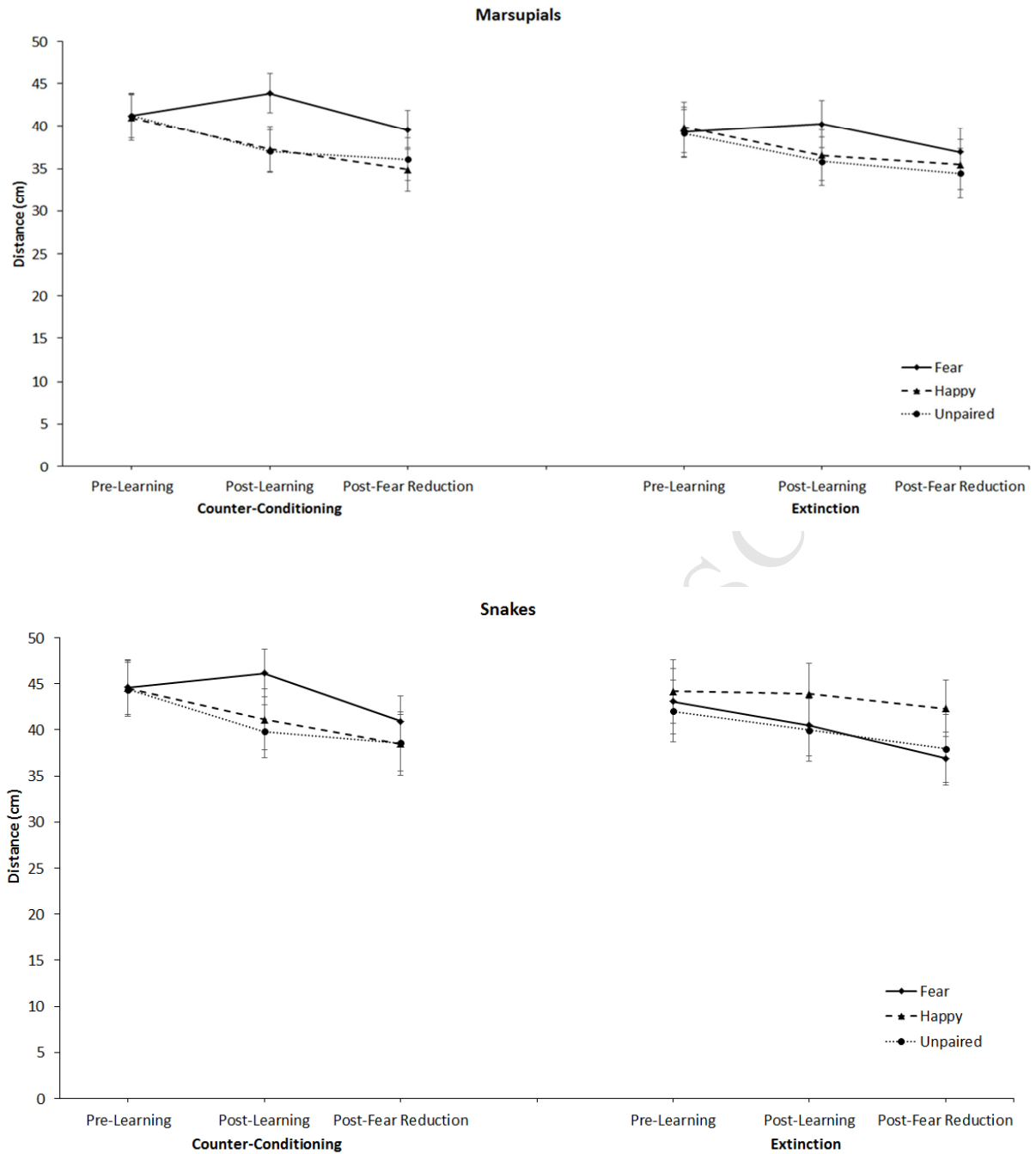
Figures 6a and 6b. Mean (and SE) avoidance preferences for fear-paired, happy-paired, and unpaired (control) marsupials and snakes CSs, pre-learning, post-learning, and post-fear reduction for the counterconditioning and extinction groups (Experiment 3).

Highlights

- Children (6-10 years) can vicariously learn fear of snakes, marsupials and flowers.

- Children do not vicariously learn fear for marsupials more rapidly than for fear-irrelevant flowers.

- Children's vicariously learned fear is neither greater in magnitude nor more robust for snakes compared to marsupials, or marsupials compared to flowers.

- For children in this age group, stimulus fear relevance may not influence vicarious fear learning because of heightened vulnerability to external threats in childhood: Learning rapidly, robustly, and unselectively from adults about all potential threats may offer the best survival advantages.