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Learning to fear a second-order stimulus following vicarious learning

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ABSTRACT

Vicarious fear learning refers to the acquisition of fear via observation of the fearful responses of others. The present study aims to extend current knowledge by exploring whether second-order vicarious fear learning can be demonstrated in children. That is, whether vicariously learnt fear responses for one stimulus can be elicited in a second stimulus associated with that initial stimulus. Results demonstrated that children's (5–11 years) fear responses for marsupials and caterpillars increased when they were seen with fearful faces compared to no faces. Additionally, the results indicated a second-order effect in which fear-related learning occurred for other animals seen together with the fear-paired animal, even though the animals were never observed with fearful faces themselves. Overall, the findings indicate that for children in this age group vicariously learnt fear-related responses for one stimulus can subsequently be observed for a second stimulus without it being experienced in a fear-related vicarious learning event. These findings may help to explain why some individuals do not recall involvement of a traumatic learning episode in the development of their fear of a specific stimulus.

Vicarious fear learning refers to the process of learning fear through observing the fearful reactions of others. In the 1980s and 1990s, Mineka and Cook provided significant support for the acquisition of fear in rhesus monkeys via vicarious learning (e.g. Cook & Mineka, 1987; Mineka & Cook, 1993). They showed that rhesus monkeys that were reared in a laboratory did not show the fear of snakes that is evident in rhesus monkeys in the wild but rapidly acquired an intense fear of snakes when observing wild-reared monkeys behave fearfully in the presence of a snake (see Mineka & Cook, 1988, for a review). Subsequently, robust vicarious fear learning effects have been widely documented in children (e.g. Askew, Dunne, Özdil, Reynolds, & Field, 2013; Askew & Field, 2007; Askew, Kessock-Philip, & Field, 2008; Dunne & Askew, 2013; Reynolds, Field, & Askew, 2014).

Like direct conditioning, vicarious learning is argued to be underpinned by associative learning mechanisms (e.g. Askew & Field, 2008; Field, 2006; Mineka & Cook, 1993); however, research is required to establish which characteristics of associative learning are specifically shared by vicarious learning. One such potential characteristic is second-order conditioning (Rescorla, 1980): a type of higher order conditioning whereby a learnt response to one stimulus is also found for a second stimulus with which it subsequently becomes associated. That is, initial training (first-order conditioning) involves pairing a neutral conditioned stimulus (CS_1) with a traumatic unconditioned stimulus (US) and consequently the CS_1 elicits a conditioned response (CR). This is then followed by second-order conditioning whereby CS_1 is paired with a second neutral stimulus (CS_2). If successful, this second-order conditioning leads to CS_2 becoming associated with CS_1 and therefore CS_2 elicits a CR similar to that elicited by CS_1 despite not being exposed to the original US. Second-order conditioning

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is thus a process through which learned fears can, via additional associations, transfer to other stimuli and contribute to the development of clinical anxiety patterns. It has been widely demonstrated, particularly in rats (e.g. Rizley & Rescorla, 1972), but also humans (e.g. Davey & Arulampalam, 1982).

Second-order conditioning following vicarious learning has been demonstrated in monkeys. Cook and Mineka (1987) first exposed rhesus monkeys to vicarious learning that resulted in the acquisition of a fear of snakes. The monkeys were then exposed to six sessions of second-order conditioning whereby a black-striped box (the second-order CS) was paired with a snake (first-order CS). Results demonstrated small but significant levels of fear conditioned to the second-order CS. These results showed that fear can be elicited after the presentation of a second stimulus if this stimulus has been presented contiguously with the feared stimulus, even though this second stimulus has never received conditioning with an aversive US.

The fear associated with the second stimulus was not as robust as that associated with the feared stimulus, reminiscent of early findings of second-order conditioning following direct first-order classical conditioning. Arguably, this may be the result of too many second-order conditioning pairings leading to the second-order CS acquiring inhibitory properties causing extinction of the CR (e.g. Rescorla, 1980). Alternatively, Cook and Mineka (1987) use Seligman's (1971) theory of preparedness to argue that the second stimulus lacked fear relevance, and thus failed to elicit a strong fear response. It makes sense from an evolutionary perspective that only fear-relevant stimuli pose a threat to the survival of monkeys and thus vicarious learning would only occur for these fear-relevant stimuli, and this has received wide support (e.g. Mineka & Öhman, 2002; however, see also Askew et al., 2013).

Demonstration of second-order conditioning in vicarious learning in children would expand understanding of the parallels between direct conditioning and vicarious learning, and add to knowledge about the role of vicarious learning in children's fears. That is, evidence for second-order conditioning following vicarious fear learning would demonstrate how additional stimuli may become feared without being involved in the original vicarious learning situation. Research has suggested that some fears may be the result of second-order conditioning rather than first-order conditioning (e.g. Cook & Mineka,

1987; Rizley & Rescorla, 1972) and therefore the feared stimulus may never have been directly paired with a traumatic event. For example, Davey and Arulampalam (1982) used aversive electrodermal conditioning to demonstrate first-order conditioned skin conductance responses following pairings of a triangle (CS_1) with an aversive loud noise (US), followed by second-order conditioned skin conductance responses to a different figure (CS_2) that was only ever paired with CS_1 and never with the US. Clinically, second-order conditioning could explain why many phobic individuals cannot recall a traumatic experience with their feared stimulus: because learning occurred via a second stimulus rather than through experiencing an aversive event directly (see Davey, 1997). In which case, clinical interventions should target breaking the association between these two stimuli.

Second-order vicarious fear learning has been demonstrated in monkeys (Cook & Mineka, 1987) but never in children and would (1) indicate that vicariously learnt fear responses for one stimulus can be elicited in a second associated with that stimulus, (2) explain why phobic individuals often have no memory of a negative learning experience with their feared stimulus and (3) suggest how interventions might be more specifically targeted. Therefore, in line with previous research demonstrating second-order conditioning following vicarious fear learning in monkeys, the current experiment predicted that increases in fear-related responses (fear cognitions, avoidance preferences and behavioural avoidance) for a fear-paired animal (CS_1^+) would also be found for a second animal (CS_2^+; second-order stimulus) never seen with fearful faces (US) if it is presented together with the first stimulus (CS_1^+).

Methods

Participants

Fifty-two children from a primary school in Basildon, Essex (29 males and 23 females) with an age range of 7.2–9.15 years with a mean of 96.96 (SD = 7.48) months took part in the experiment. Parents were given consent forms to sign on an opt-in basis, 2 weeks prior to the research. Only children with signed consent forms participated, and all children gave verbal assent before they began the study. The study was approved by a Kingston University, London ethics committee.

Materials

The majority of the study was automated, using a programme written in E-Prime 2.0 by the first author, on a Samsung RF511 Laptop and a ProLite T2451MTS 24 in. Touchscreen Monitor.

Animals

Two Australian marsupials (a quokka and a cuscus) and two caterpillars (an automeris and a nymphalis) were used as CSs. These marsupials are unlikely to be known by most UK children, ensuring that they did not have pre-existing fear beliefs. Although, like marsupials, children may be familiar with caterpillars generally, the types used in the current research are unlikely to be familiar to UK children. All four animals have been successfully used in previous similar vicarious learning studies (see e.g. Askew et al., 2013; Askew & Field, 2007; Dunne & Askew, 2013). Ten colour pictures of each animal, measuring 346 pixels wide by 444 pixels high, were used. The study was counterbalanced so that for half the children, marsupials were used as CS_1 and pictures of caterpillars as CS_2 and for half the children caterpillars were used as CS_1 and marsupials as CS_2.

Faces

Ten pictures (also measuring 346×444) of scared adult faces (five males and five females) were taken from the NimStim Face Stimulus Set (Tottenham, Borscheid, Ellertsen, Marcus, & Nelson, 2002) to use as USs during vicarious learning.

Fear Beliefs Questionnaire

An automated Fear Beliefs Questionnaire (FBQ: Field & Lawson, 2003) was used to measure fear beliefs for the four animals twice during the experiment. The FBQ includes seven questions for each animal (28 in total); for example, "Would you keep your distance if you saw a QUOKKA?", and was displayed on the monitor with a picture of the marsupial or caterpillar in question. Children responded 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") by touching the screen. Internal consistency was high before vicarious learning: Cronbach's $\alpha = .67$ (Quokka subscale), .77 (Cuscus subscale), .78 (Automeris subscale) and .81 (Nymphalis subscale); and after learning: $\alpha = .81, .82, .85$ and .79, respectively.

Nature Reserve Task

The nature reserve task (NRT; Field & Storksen-Coulson, 2007) comprised of a rectangular board (680 mm × 500 mm) covered with green felt and pipe cleaner trees and fences representing a nature reserve. The children were asked to imagine that the embellished board was a nature reserve containing one of the marsupials or caterpillars, represented by a picture, at the end of the reserve. They then placed a plastic figure representing themselves in the reserve to determine how near or far from the animal they would prefer to be. The distance between the figure and picture of the marsupial/caterpillar was measured to determine avoidance preference. The procedure was repeated for the four animals; the order of presentation was counterbalanced across participants.

Behavioural Avoidance Task

The behavioural avoidance task (BAT: Field & Lawson, 2003, see Askew & Field, 2007; Field & Lawson, 2003; Kelly, Barker, Field, Wilson, & Reynolds, 2010) comprised of four pet-carrier boxes (size: 260 mm × 460 mm × 340 mm) ostensibly containing the marsupials and caterpillars, complete with breathing holes and one larger hole (diameter: 14 cm) covered with hessian as a touch hole. A picture of each caterpillar and marsupial was displayed on the box. Children began the task by standing on a line placed 1 m from the boxes. Children were given 15 s to approach the first box and put their hand into the box up to their wrist. The time it took to approach the box was taken during these 15 s. If the child did not approach the box within 15 s, it was taken that they did not wish to approach that animal. Children returned back to the line and repeated the procedure for the remaining three boxes.

Procedure

The experiment lasted approximately 20 min and took place in a quiet room of the school with each child participating individually. Children first completed the first NRT followed by the first FBQ to assess baseline avoidance preferences and fear cognitions for marsupials and caterpillars. Vicarious learning consisted of 10 presentations of pictures of one marsupial or caterpillar (CS_1^+) on the left side of the screen together with a scared face (fear US) on the right side of the screen, and 10 pictures of the second marsupial or caterpillar presented alone on the left-hand side of the screen

(CS_1^-). The animal appeared first for 1 s, accompanied by the picture of the face (or no face) for a further 1 s. There was a variable inter-trial interval of between 2 and 4 s (see Askew & Field, 2007; Askew et al., 2008). Trials were presented in random order and whether the animal was fear-paired or unpaired was counterbalanced across children.

Directly following vicarious learning, with no interval, children were presented with the second-order conditioning phase. This phase was structurally identical to vicarious learning, using the same number of trials used in initial conditioning in order to maintain consistency across conditioning sessions. Using the same number of trials as conditioning also prevents conditioned inhibition potentially accruing to the second-order stimulus, which can happen if the second-order conditioning phase contains substantially more trials than the original conditioning phase. For children who were presented with pictures of marsupials during vicarious learning, one of the caterpillars (CS_2^+) was presented with pictures of the previously fear-paired marsupial (CS_1^+) for 10 pairing trials, and pictures of the second caterpillar (CS_2^-) were presented together with the previously unpaired marsupial (CS_1^-) for 10 pairing trials. The location of the stimuli on the left- or right-hand side of the screen was randomised. For children who were initially presented with pictures of caterpillars during vicarious learning, pictures of marsupials were displayed during this phase. Presentation method, trial length and inter-trial intervals were the same as for vicarious learning.

Following this, the FBQ and NRT were completed for a second time for marsupials and caterpillars to explore changes in fear beliefs and avoidance preferences resulting from vicarious learning and second-order conditioning. Finally, children were invited to participate in the BAT. At the end of the experiment, all children were fully debriefed with verbal explanations, written information and age-appropriate worksheets, so that any false impressions about the marsupials or caterpillars were corrected. Children were also shown that the pet-carrier boxes did not contain the animals and were actually empty.

Results

A rejection criterion of $\alpha = .05$ was used for all analyses and effect sizes (r) are reported. Cohen's (1988) suggestions about what constitutes a large or small effect are: $r = .10$ is a small effect; $r = .30$ is a medium effect and $r = .50$ is a large effect.

Fear beliefs

Figure 1 shows the mean fear-belief scores for the CS_1^+, CS_1^-, CS_2^+ and CS_2^- before and after vicarious learning, and shows increases in fear beliefs following vicarious learning for CS_1^+ (pre-learning, $M = 1.90$, SD = 0.91, 95% CI [1.65, 2.15], post-learning, $M = 2.51$, SD = 0.98, 95% CI [2.25, 2.77]) and to a slightly lesser extent, for CS_2^+ (pre-learning, $M = 1.91$, SD = 0.90, 95% CI [1.67, 2.16], post-learning, $M = 2.29$, SD = 1.08, 95% CI [2.00, 2.59]). There were small increases in fear beliefs for CS_1^- (pre-learning, $M = 1.89$, SD = 0.90, 95% CI [1.64, 2.14], post-learning $M = 1.96$, SD = 1.00, 95% CI [1.71, 2.22]) and CS_2^- (pre-learning, $M = 1.81$, SD = 1.04, 95% CI [1.52, 2.10], post-learning, $M = 1.93$, SD = 1.01, 95% CI [1.65, 2.20]).

A four-way 2 (time: pre-learning vs. post-learning) × 2 (pairing type: fear vs. unpaired) × 2 (stimulus: CS_1 vs. CS_2) × 2 (animal type: marsupial vs. caterpillar) mixed ANOVA with repeated measures on the first three variables was conducted on average fear-belief scores. Initially, age was entered as a covariate but did not significantly predict fear beliefs and was not included in further analyses. Results indicated a significant main effect of time, $F(1, 50) = 19.30$, $p < .001$, $r = .53$, and pairing type, $F(1, 50) = 13.55$, $p = .001$, $r = .46$, but no significant main effect of stimulus ($F < 1$). The time × stimulus and pairing × stimulus interactions were non-significant, ($Fs < 1$). The time × pairing type interaction was significant, $F(1, 50) = 15.05$, $p < .001$, $r = .48$, indicating vicariously learnt increases in fear beliefs for paired stimuli (CS_1^+ and CS_2^+) compared to unpaired stimuli (CS_1^- and CS_2^-). There was no
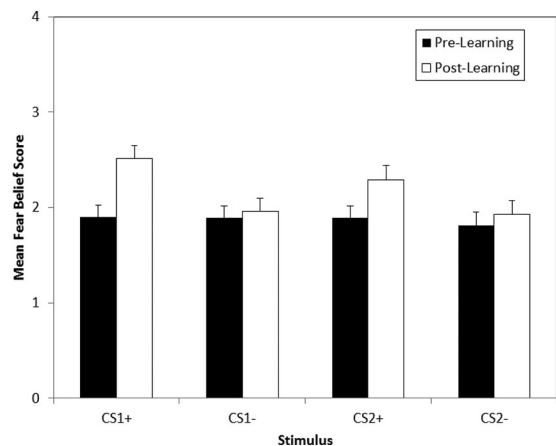

Figure 1. Mean (and SE) fear-belief scores for CS_1^+, CS_1^-, CS_2^+ and CS_2^- before and after learning.

significant time × stimulus × pairing type interaction, $F(1, 50) = 2.31$, $p = .14$, $r = .21$, so vicarious learning was not significantly different for CS_2 compared to CS_1.

Because the demonstration of equivalent learning in standard vicarious learning and second-order conditioning hinged on a null effect, we computed a Bayes factor for the three-way interaction. Rather than asking whether or not this interaction is significant, this statistic quantifies the ratio of the probability of the data under the alternative hypothesis relative to the null. A value of 1 means that the probability of the data is equal under the null and alternative hypotheses, values above 1 suggest that the probability of the data is greater under the alternative hypotheses relative to the null and values below 1 suggest that the probability of the data is greater under the null hypotheses relative to the alternative. The Bayes factor was computed using the anovaBF function in the Bayes-Factor (Morey & Rouder, 2014) package in R (R Core Team, 2015). This function uses a default Jeffreys prior (Rouder, Morey, Speckman, & Province, 2012). The Bayes factor for the three-way interaction term was 0.287 (±2.36%), suggesting strongly that the probability of the data is greater under the null hypothesis than the alternative hypothesis. This finding supports the hypothesis that the data indicate equivalent conditioning in directly conditioned and second-order CSs.

There were no significant main effects or interactions with animal type, with the exception of a significant stimulus × animal type interaction, $F(1, 50) = 15.36$, $p < .001$, $r = .48$; therefore, there was no indication that learning was significantly greater for one animal type compared to another. Taken together, these results provide evidence for second-order fear conditioning.

Avoidance preferences

Figure 2 shows the mean distance (mm) on the nature reserve board from each CS_1 and CS_2. The graph demonstrates an increase in avoidance preferences for CS_1^+ (pre-learning, $M = 348.12$, SD = 213.60, 95% CI [288.03, 408.20], post-learning, $M = 362.25$, SD = 215.77, 95% CI [301.73, 422.77]) and CS_2^+ (pre-learning, $M = 287.50$, SD = 171.62, 95% CI [239.80, 335.21], post-learning, $M = 313.13$, SD = 179.82, 95% CI [263.33, 362.94]) and a decrease in avoidance preferences for CS_1^- (pre-learning, $M = 303.63$, SD = 194.94, 95% CI [250.16, 357.11], post-learning, $M = 264.10$, SD = 189.67, 95% CI [215.12, 313.07]). There was also a

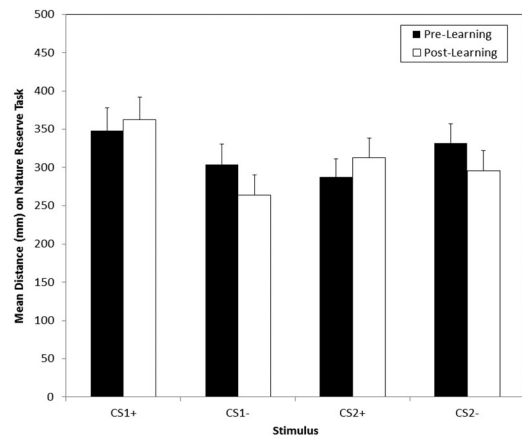**Figure 2.** Mean distances (mm) from CS_1^+, CS_1^-, CS_2^+ and CS_2^- in the NRT before and after learning.

decrease in avoidance preferences over time for CS_2^- (pre-learning, $M = 331.90$, SD = 180.93, 95% CI [281.97, 381.84], post-learning, $M = 295.92$, SD = 186.37, 95% CI [243.90, 347.95]).

A four-way 2(time: pre-learning vs. post-learning) × 2(pairing type: fear vs. unpaired) × 2(stimulus: CS_1 vs. CS_2) × 2(animal type: marsupial vs. caterpillar) mixed ANOVA, with repeated measures on the first three variables, conducted on average distances (mm) from each marsupial and caterpillar CS in the NRT indicated no significant main effects of stimulus or time ($F < 1$), but there was a significant main effect of pairing type, $F(1, 50) = 5.14$, $p = .03$, $r = .31$. More important, a significant time × pairing interaction showed a significant vicarious learning effect in which increases in avoidance preferences for paired CSs were greater than for unpaired CSs, $F(1, 50) = 11.88$, $p = .001$, $r = .44$. The pairing type × stimulus interaction was also significant, $F(1, 50) = 11.19$, $p = .002$, $r = .43$. However, there was no significant time × stimulus interaction, or time × stimulus × pairing type interaction ($Fs < 1$), demonstrating that although avoidance preferences increased over time for paired stimuli (CS_1^+ and CS_2^+) compared to unpaired stimuli (CS_1^- and CS_2^-), there was no significant difference in increases for CS_1 compared to CS_2. The Bayes factor for the critical three-way interaction was 0.201 (±0.94%), which strongly suggests that the probability of the data was greater under the null hypothesis than the alternative. Analyses with animal type indicated a significant stimulus × animal type interaction, $F(1, 50) = 6.44$, $p = .01$, $r = .34$, pairing type × animal type interaction, $F(1,$

50) = 4.03, $p = .05$, $r = .27$, stimulus × pairing type × animal type interaction, $F(1, 50) = 4.11$, $p = .048$, $r = .28$, but these effects did not include an interaction with time.

Behavioural avoidance

Only 5 of 52 children opted to take part in the touch box task and all five children placed their hand in each of the four boxes. The remaining 47 children did not wish to approach the animals. Due to the small numbers of children opting to approach the animals, the BAT results could not be analysed.

Discussion

The current experiment explored whether fear-related responses to a second-order stimulus could occur following vicarious fear learning. Analysis of fear-belief responses replicated previous research (e.g. Askew & Field, 2007) showing that children's fear beliefs for marsupials and caterpillars increase when they see them with fearful faces compared to seeing them with no faces. Avoidance preference results were also in-line with previous studies (e.g. Reynolds et al., 2014), showing increased avoidance following vicarious learning. Thus, seeing someone responding fearfully to a novel stimulus increases children's fear beliefs and avoidance preferences for that stimulus. Furthermore, the results indicated a second-order effect in which fear-related learning occurred for a second animal seen together with the animal that had previously been paired with scared faces, even though the second animals were never directly paired with fearful faces themselves. Analyses indicated that the type of animal (i.e. caterpillar or a marsupial) used as first- or second-order stimulus had no significant effect on learning.

From a theoretical perspective, the current experiment indicates that vicarious learning shares an important characteristic of associative learning: second-order conditioning (Rescorla, 1980). Similar findings have been found with monkeys (Cook & Mineka, 1987), but to our knowledge, this is the first demonstration in children of second-order conditioning following vicarious fear learning. The results indicate that fear beliefs and avoidance can increase for a stimulus that has not been directly involved in a learning event, but can simply be associated with another stimulus that was previously involved in a fear-related vicarious learning event. Clinically, this is a potential explanation for why some individuals develop a particular fear or phobia but are unable to remember a traumatic experience with the feared stimulus (e.g. Davey, 1997). The feared stimulus may not have been directly involved in a fear-related modelling experience but have become associated with another stimulus that has. Thus, the individual may have no traumatic memory directly with the stimulus. Interventions might be targeted at breaking the association between these two stimuli (CS_1 and CS_2), and also between the original "hidden" stimulus (CS_1) and the model's fear response (US), neither of which may initially be obviously associated with the current feared stimulus (CS_2).

A potential alternative explanation of the results is that second-order conditioning might reflect direct stimulus–response (S–R) learning rather than stimulus–stimulus (CS_1–CS_2) learning. Recent research (Reynolds, Field, & Askew, 2015) used an US revaluation procedure to dissociate between CS–US and S–R associations, and provided evidence that CS–US associations underpin vicarious learning. However, it may be that second-order learning results from a direct association between the CS_2 and the CR elicited by the CS_1 rather than the CS_1 itself. In this scenario, second-order vicarious learning might represent a form of evaluative conditioning (EC). Procedurally, Pavlovian and EC are the same in that CRs result from pairing temporally contiguous stimuli, but functionally they are different (Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). For example, theoretical accounts of EC suggest that, unlike Pavlovian conditioning, CRs are driven not only by direct associations formed between the CS and US, but also by a direct link between the CS and the evaluative *response* to the US; recent data have substantiated this claim (e.g. Gast & Rothermund, 2011). The current study cannot disentangle whether the second-order conditioning effects were driven by the formation of a CS_2–CS_1 association or a CS_2–CR_1 association because responses to CS_1 were not measured during the second-order conditioning phase and there was no sensory-preconditioning condition. Consequently, it is unclear whether the conditioned fear responses observed to the second-order CS in the current study resulted from stimulus–stimulus associations or from stimulus–response associations; which also means it is unclear whether the learning resulted from Pavlovian or EC. If the process was evaluative then this has implications for the durability of second-order CRs; for example, they should be more resistant to extinction than if they are driven by Pavlovian mechanisms (e.g. Hofmann et al., 2010).

In conclusion, the current study further supports that vicarious learning is sufficient to increase self-reported fear beliefs and avoidance preferences for novel animals, and additionally demonstrated that this increase in fear beliefs can transfer to a second stimulus not involved in the original learning event. The findings may help explain why some individuals are unable to recall a traumatic event associated with their fear or phobia as well as informing how interventions should be targeted. Future research could explore these interventions. For example, Davey and Arulampalam (1982) demonstrated that extinguishing the first-order fear response does not necessarily also extinguish the second-order fear response. If this is found to be the case for second-order vicarious learning, then this could have important implications for the treatment of vicariously acquired fears and phobias.

Disclosure statement

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