

Other People as Means to a Safe End: Vicarious Extinction Blocks the Return of Learned Fear

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Abstract

Information about what is dangerous and safe in the environment is often transferred from other individuals through social forms of learning, such as observation. Past research has focused on the observational, or vicarious, acquisition of fears, but little is known about how social information can promote safety learning. To address this issue, we studied the effects of vicarious-extinction learning on the recovery of conditioned fear. Compared with a standard extinction procedure, vicarious extinction promoted better extinction and effectively blocked the return of previously learned fear. We confirmed that these effects could not be attributed to the presence of a learning model per se but were specifically driven by the model's experience of safety. Our results confirm that vicarious and direct emotional learning share important characteristics but that social-safety information promotes superior down-regulation of learned fear. These findings have implications for emotional learning, social-affective processes, and clinical practice.

Keywords

vicarious learning, observational learning, fear, extinction, reinstatement, learning, emotions, social cognition

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Learning to fear potentially dangerous objects and people in the environment is crucial for survival. Of equal importance, however, is learning to regulate past fears in light of new information indicating that what was previously dangerous is now safe. Much of the information about what is safe and approachable in the environment comes from other individuals through social forms of learning, such as verbal instruction, observation, or a combination of these. For example, fear of a specific individual might diminish and eventually disappear after one repeatedly watches a trusted person calmly interacting with the feared person and suffering no aversive consequences. Previous research on the attenuation of learned fears has, however, focused on the role of direct, nonreinforced exposure to the feared object in the process of extinction (see Rescorla, 2000, for a review). In contrast, research on social forms of fear learning has centered on the acquisition of fears (Askew & Field, 2008; Hygge & Öhman, 1978; Mineka & Cook, 1993; Olsson & Phelps, 2007). Aiming to extend the understanding of both extinction and social learning, and the integration of

these processes, we examined how observational (vicarious) safety learning could diminish the expression of learned fear.

Apart from having an important role in daily social interaction, vicarious safety learning has long been exploited as a part of exposure treatment of phobias. In such treatment, the phobic individual watches the therapist—acting as a learning model—approach and interact with the feared stimulus before the phobic individual is directly exposed to it (Seligman & Wuyek, 2005). Earlier behavioral research (Bandura, Grusec, & Menlove, 1967; Hill, Liebert, & Mott, 1968; Ritter, 1968) has tried to capture the underlying processes of this form of vicarious treatment, but these studies suffered from several methodological limitations, such as unsatisfactory control conditions. Other limitations of these early studies, as well as

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of the few existing more recent studies (Gilroy, Kirkby, Daniels, Menzies, & Montgomery, 2001), are the inclusion only of phobic participants, which prevents generalizing results to healthy individuals, and a reliance on behavioral measures. Over the last decade, the fields of social learning and emotional learning have developed rapidly in terms of both theory and methods, which has paved the way for improved experimental manipulations in conjunction with physiological measures known to be coupled with brain systems regulating the acquisition and extinction of learned fear.

The study of social forms of emotional learning has mainly targeted the acquisition of fears. This growing literature has highlighted similarities to direct fear conditioning (Askew & Field, 2008; Hooker, Verosky, Miyakawac, Knight, & D'Esposito, 2008; Hygge & Öhman, 1978; Kelly & Forsyth, 2009; Olsson, Nearing, & Phelps, 2007; Olsson & Phelps, 2004). For example, learning acquired both vicariously and directly can be expressed without conscious awareness of the learned fear stimuli (Olsson & Phelps, 2004), and both involve the amygdala bilaterally during acquisition and expression (Olsson et al., 2007). However, in spite of such similarities, there are also important differences prompted by the additional information available about the learning model during vicarious learning. Indeed, appraisal of the other person's pain can affect the observer's emotional responses, as well as the ensuing learning. This is illustrated by the fact that taking the perspective of someone in pain can enhance both affective sharing (empathy) at the time of perspective taking (Lamm, Batson, & Decety, 2007) and learned fear of stimuli perceived to be predictive of the other person's pain, as measured at a later point in time (Olsson et al., 2013). These results suggest that the emotional experiences attributed to the learning model can have a considerable impact on vicarious learning. Currently, however, little is known about the processes enabling learning to attenuate fears through social observation.

Considerably more is known about the attenuation of learned fear through direct exposure, which is known as *extinction learning*. Because fear extinction can be used as an experimental model of exposure-based therapies for anxiety disorders (Bouton, Mineka, & Barlow, 2001; Milad & Quirk, 2012; Mineka & Zinbarg, 2006), the underlying mechanisms of this form of learning have attracted much interest over the past decade (Craske et al., 2008; Milad & Quirk, 2012; Myers & Davis, 2007; Phelps, Delgado, Nearing, & LeDoux, 2004).

The extinction of conditioned fear can be studied experimentally with protocols in which the expression of a conditioned fear response is weakened through repeated exposures to a conditioned stimulus, such as a facial image, in the absence of its associated aversive consequence, the unconditioned stimulus, such as an

unpleasant electric shock. According to an influential account proposed by Bouton (1993), extinction represents an inhibitory learning process involving learning of a new "safety memory" that competes with the original learning of the association between the conditioned and unconditioned stimulus. This inhibitory-learning account of extinction is supported by the return of the original fear memory, which is illustrated by postextinction phenomena, such as reinstatement, during which a previously extinguished conditioned fear response reappears following reexposure to the unconditioned stimulus (Rescorla & Heth, 1975). The recovery of the conditioned fear response after extinction, as routinely seen following direct exposure to unreinforced conditioned stimuli, parallels the well-documented clinical phenomenon of relapse after a successfully completed fear-exposure treatment.

In the current study, we drew on the understanding of direct extinction learning and work on social-emotional learning to examine whether the attenuation of learned fears can be facilitated through watching the safety behavior of a learning model undergoing extinction training. Past evidence of the efficiency of a learning model in transferring emotionally relevant information through demonstration led us to reason that the safety learning provided by watching the model's calm exposure to the previously aversive conditioned stimulus would facilitate the extinction process. Accordingly, we predicted that, compared with standard, direct extinction, vicarious extinction would be more effective in diminishing the conditioned fear response during extinction and during a subsequent test of fear recovery.

Method

Participants

Forty-nine male participants were recruited and were paid for their participation in the study, which was approved by the local ethics committee. We excluded 2 outliers because their skin conductance responses (SCRs) were above or below 3 standard deviations from the mean in the acquisition, extinction, or reinstatement stages, and 4 subjects were excluded because they failed to report the correct contingency between the conditioned and unconditioned stimulus, as revealed by a postexperiment interview. An additional 7 subjects were excluded from the vicarious-extinction group after claiming to have seen the model receiving shocks during the extinction stage, thus failing to correctly report a critical element of the experimental manipulation.¹ The final sample consisted of 36 male participants (direct-extinction group: $n = 20$; mean age = 25.8 years, $SD = 5.34$; vicarious-extinction group: $n = 16$; mean age = 23.7 years, $SD = 5.90$).

Materials

Two pictures depicting angry male faces from the Karolinska Directed Emotional Faces database (Lundqvist, Flykt, & Öhman, 1998) served as conditioned stimuli (Items AM02ANS and AM06ANS). The unconditioned stimulus consisted of a 100-ms DC-pulse electric stimulation (administered using the STM200; BIOPAC Systems) applied to the participant's right wrist. The coupling between a specific conditioned face stimulus and the unconditioned stimulus, and the order of presentation of the two conditioned stimuli, was counterbalanced between participants.

Using Adobe Premiere Pro CS5.5, we created one movie that was 4 min and 18 s in length for each of the two conditions of the extinction stage. Both movies showed a computer screen on which we presented both the conditioned stimuli (i.e., both the conditioned stimulus previously accompanied by a shock, CS+, and the conditioned stimulus without a shock, CS−). The movie for the vicarious-extinction condition contained a calm learning model sitting in front of the screen watching the conditioned-stimulus presentations. Apart from the addition of the learning model, both movies were identical in terms of content and timing.

Data acquisition

Skin conductance was measured by a pair of Ag-AgCl electrodes attached to the distal phalanges of the index

finger of the left hand. The physiological signals were amplified and recorded using BIOPAC Systems (Santa Barbara, CA) hardware at a rate of 250 samples per second. Data were analyzed using AcqKnowledge software (BIOPAC Systems).

Procedure

Before the experiment started, the shock level was adjusted individually to be “unpleasant but not painful.” Throughout all experimental stages, each conditioned stimulus was presented for 6 s. A white fixation cross was shown on a black background for 12 to 15 s during the interstimulus intervals. The experiment began with a habituation stage during which two nonreinforced presentations of each conditioned stimulus were presented. Following this, participants were informed that there would be a specific contingency between the faces shown on the screen and the administration of a shock (the unconditioned stimulus), and they were asked to pay notice to and remember this contingency. However, no information was given about what specific face was paired with the shock. During the subsequent acquisition stage (Fig. 1a), one of the faces (CS+) coterminated with the presentation of the unconditioned stimulus on six out of nine presentations, whereas the other face (CS−) was never coupled to the unconditioned stimulus (i.e., nine nonreinforced presentations). After the acquisition stage, participants in the vicarious-extinction group received the following written instruction:

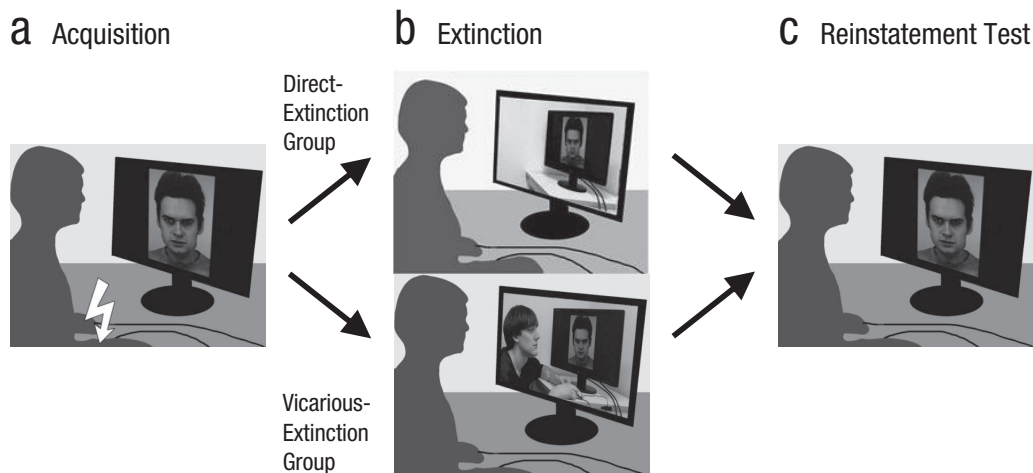


Fig. 1. Paradigm in the main experiment. During the acquisition stage (a), participants saw two faces, presented separately. One of the faces (shown here) coterminated with the presentation of the unconditioned stimulus (an electric shock), whereas the other face was never coupled to the unconditioned stimulus. During the subsequent extinction stage (b), the vicarious-extinction group saw a movie in which a learning model received nonreinforced presentations of each conditioned stimulus and reacted calmly. The direct-extinction group saw an identical movie but without the learning model. To assess the effects of vicarious extinction on the recovery of learned fear, we gave all participants three unsigned shocks, followed by a reinstatement-test stage (c) in which each conditioned stimulus was presented without accompanying shocks.

During the next stage, you will watch a movie of a person participating in an experiment similar to the one you have been doing. The person is attached to the same equipment and is watching the same faces as you. Remember to attend to the picture display.

Participants in the direct-extinction group received similar instructions with the exception of the information regarding the model: "During the next stage you will watch a movie of an experiment similar to the one you have been doing. Remember to attend to the picture display."

The extinction stage (Fig. 1b) followed immediately after the instructions. Both extinction groups watched a movie including six nonreinforced presentations of each conditioned stimulus. After the extinction movie finished, all participants received the following written instruction: "During the next stage, the setup of the experiment will be the same as before you watched the movie. The presentation will begin with a black screen. Remember to attend to the picture display."

The instruction screen was followed by a standard procedure for the reinstatement of the conditioned response (Hermans et al., 2005; Norrholm et al., 2006). This consisted of a black screen for 30 s, after which participants received three unsignaled shocks. This was followed by the reinstatement-test stage (Fig. 1c), in which each conditioned stimulus was again presented without shocks six times.

To assess their explicit awareness of conditioned stimulus-shock contingencies, we asked participants at the completion of the experiment to rate, for each experimental stage separately, how many shocks they received to each conditioned stimulus and how confident they were of having received or not having received shocks (on a scale from 1, *confident not receiving shocks*, to 7, *confident receiving shocks*). In addition, the vicarious-extinction group was asked how many shocks they experienced that the learning model received during the extinction movie.

Data reduction and response definition

The SCR was measured for each conditioned-stimulus trial as the base-to-peak amplitude of the first response (in microsiemens, μS) in the latency window from .5 to 4.5 s following stimulus onset. The minimal response criterion was set to .02 μS , and responses that did not pass this criterion were scored as 0. The raw SCR scores were first filtered and then z -transformed to normalize the distributions. Each stage of the experiment (acquisition, extinction, and reinstatement test) was analyzed separately. To decrease trial-by-trial variability, we averaged

and analyzed the data as two blocks (early vs. late) during the extinction and reinstatement-test stage. Thus, each block was defined as the mean SCR across three consecutive CS+ or CS- trials. We adopted a significance level of .05, reporting only effects not qualified by a significant higher-order interaction.

Results

Fear acquisition

Fear acquisition was assessed using a repeated measures analysis of variance with stimulus (CS+, CS-) as a within-subjects variable and group (direct extinction, vicarious extinction) as a between-subjects variable. This analysis revealed successful CS+/CS- differentiation (i.e., the ability to differentiate between the conditioned stimulus that was associated with a shock and the conditioned stimulus that was not), as indicated by a significant main effect of stimulus, $F(1, 34) = 153.83, p < .001, \eta^2 = .82$. As predicted, the extinction groups did not differ during the acquisition stage (see Fig. 2), as shown by the absence of an interaction involving group across acquisition training, $F(1, 34) = 0.51$, or during the end of acquisition—last four trials: $F(1, 34) = 0.35$.

Extinction and reinstatement testing

During the extinction stage, there was a significant Stimulus \times Group interaction, $F(1,34) = 12.66, p < .001, \eta^2 = .27$. A follow-up paired samples t test revealed that whereas direct extinction led to significant CS+/CS- differentiation across the extinction stage, $t(19) = 4.43, p < .001$, vicarious extinction efficiently abolished the CS+/CS- differentiation, $t(15) = 0.12, p = .91$. Analyzing reinstatement-test performance revealed a significant Stimulus \times Group interaction, $F(1, 34) = 4.93, p = .03, \eta^2 = .13$. Whereas the direct-extinction group maintained significant CS+/CS- differentiation across the reinstatement-test stage, $t(19) = 3.59, p = .002$, the vicarious-extinction group did not differentiate between the two conditioned stimuli, $t(15) = 1.35, p = .21$. Thus, in the absence of any significant differences in CS+/CS- differentiation during the acquisition stage, vicarious extinction promoted significantly more extinction and less recovery of fear than did direct extinction (see Fig. 2).

Controlling for the presence of the learning model

To confirm that the efficient attenuation of fear could be attributed to the model's experience of nonreinforced conditioned-stimulus presentations and not simply to the presence of a learning model per se, we additionally

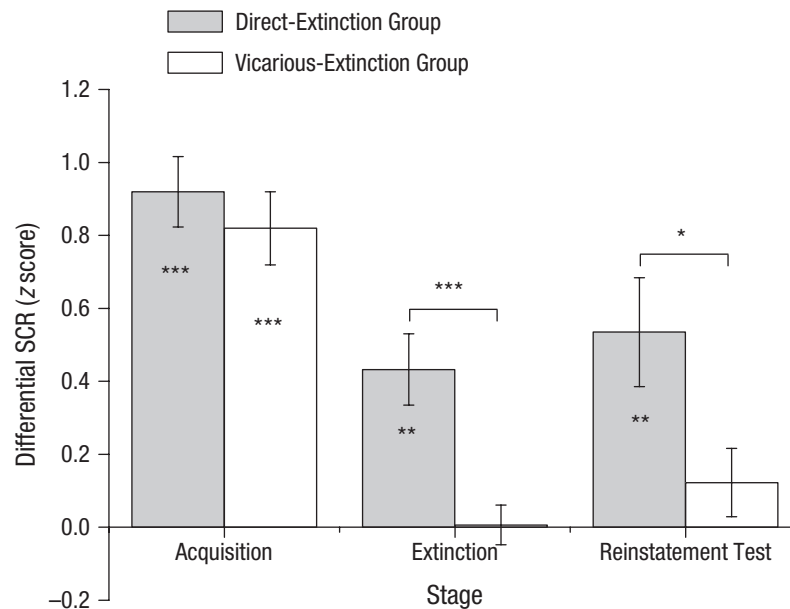


Fig. 2. Mean differential skin conductance response (SCR) as a function of experimental stage and group. Difference SCR z scores were calculated by subtracting SCRs to the face presented without an accompanying shock from SCRs to the face presented with an accompanying shock. Asterisks indicate significant differences within and between groups (* $p < .05$, ** $p < .01$, *** $p < .001$). Error bars represent standard errors of the mean.

compared the vicarious-extinction group with a new group of participants that was also exposed to the learning model during the extinction stage ($n = 19$ males, mean age = 26.2 years, $SD = 6.64$); 2 subjects were removed because they failed to correctly report the contingency between the conditioned and unconditioned stimulus, and 1 outlier was removed because of extreme SCR scores above 3 standard deviations from the mean in the acquisition stage. In this vicarious-reinforcement group, participants watched a movie identical to the one watched by the vicarious-extinction group, with one exception: The learning model received four shocks coupled with the previously reinforced conditioned stimulus. The model reacted to the shocks by slightly twitching the arm and blinking, and acted calmly when not receiving shocks. As in the vicarious-extinction group, no shocks were administered to the participants in the vicarious-reinforcement group. Acquisition and reinstatement parameters were identical to those used in the two other groups.

First, we confirmed that acquisition performance did not differ between the vicarious-reinforcement and vicarious-extinction groups. As predicted, there was a significant main effect of stimulus, $F(1, 30) = 93.90$, $p < .001$, $\eta^2 = .79$, but no differences between groups across the acquisition stage, $F(1, 30) = 1.61$, or during the last four

trials of the acquisition stage, $F(1, 30) = 0.40$. Next, we compared the groups during the extinction stage. This analysis revealed a marginally significant Stimulus \times Group interaction, $F(1, 30) = 3.26$, $p = .08$. Planned follow-up comparisons revealed that compared with vicarious reinforcement, vicarious extinction significantly reduced SCR to the CS+, $t(30) = 3.30$, $p = .01$, but not to the CS-, $t(30) = 1.23$, $p = .23$. Analyzing reinstatement-test performance revealed a significant Stimulus \times Group interaction, $F(1, 30) = 5.58$, $p = .03$, $\eta^2 = .16$. Thus, the vicarious-extinction group showed less CS+/CS- differentiation during the reinstatement test than the vicarious-reinforcement group, which maintained significantly larger SCRs to the CS+ than to the CS- across reinstatement testing, $t(15) = 3.52$, $p = .01$.

In sum, our results show that conditioned fear responses were not fully extinguished, and were subsequently reinstated, following both direct extinction and vicarious reinforcement. However, vicarious extinction effectively attenuated the fear responses and blocked their subsequent recovery. Figure 3 displays the mean conditioned fear response for the vicarious-extinction and vicarious-reinforcement groups across the three stages (acquisition, extinction, and reinstatement). Table 1 summarizes the mean SCR to CS+ and CS- for all three groups across the three stages.

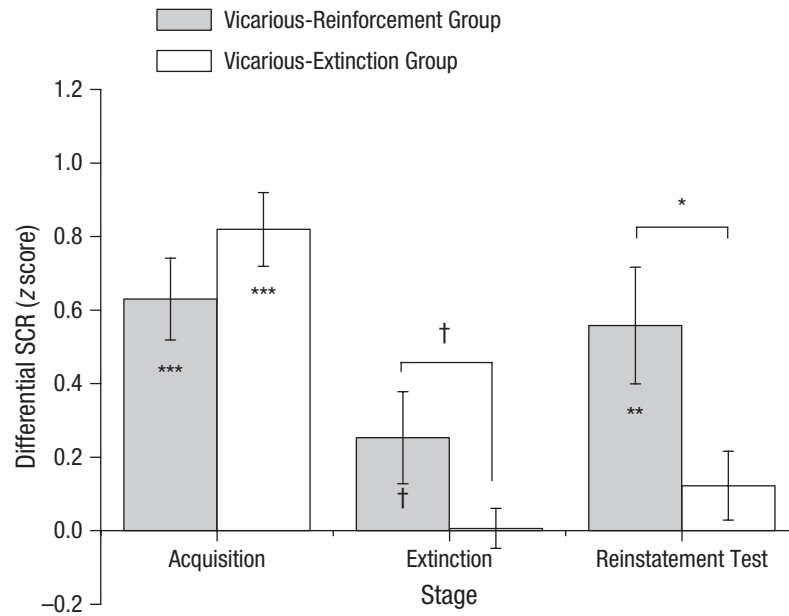


Fig. 3. Mean differential skin conductance response (SCR) as a function of experimental stage and group. Difference SCR z scores were calculated by subtracting SCRs to the face presented without an accompanying shock from SCRs to the face presented with an accompanying shock. Asterisks indicate significant differences within and between groups (* $p < .05$, ** $p < .01$, *** $p < .001$), and the dagger indicates marginally significant differences ($p < .09$). Error bars represent standard errors of the mean.

Finally, to examine whether the expectation to receive a shock during the extinction stage could have affected the group differences, we reran all analyses controlling for the individual level of confidence to receive or not receive a shock during this stage. These analyses did not alter any of the reported effects.

Discussion

Learning about what and who should be avoided and approached through observing other people's emotional

expressions, or the lack thereof, is often less risky and more economic than self-experienced trial and error. These benefits are reflected in the conservation of observational fear learning across social animals, from mice to people (Olsson & Phelps, 2007). Research on vicarious emotions in humans has shown that information about the person expressing an emotion, or the situation he or she is in, determines the extent to which emotions are shared (Hygge & Öhman, 1978; Lamm et al., 2007; Lanzetta & Englis, 1989; Zaki & Ochsner, 2012). Further, recent work suggests that such information also affects

Table 1. Mean z-Scored Skin Conductance Response (μ S) to a Face Associated With a Shock (CS+) and a Face Not Associated With a Shock (CS-) in Each Group During the Three Stages

Stage and stimulus	Direct-extinction group	Vicarious-extinction group	Vicarious-reinforcement group
Acquisition			
CS+	0.75 (0.36)	0.83 (0.44)	0.57 (0.32)
CS-	-0.17 (0.28)	0.02 (0.23)	-0.06 (0.26)
Extinction			
CS+	-0.08 (0.38)	-0.59 (0.25)	-0.21 (0.39)
CS-	-0.52 (0.26)	-0.60 (0.18)	-0.46 (0.40)
Reinstatement test			
CS+	0.26 (0.55)	0.12 (0.50)	0.38 (0.60)
CS-	-0.28 (0.31)	-0.01 (0.45)	-0.18 (0.33)

Note: Standard deviations are given in parentheses.

vicarious fear learning about stimuli predictive of the other's pain (Olsson et al., 2012). In the present study, we asked whether previously learned fears could be efficiently reduced if a person vicariously experiences another individual's safety learning. As predicted, our results showed that vicarious extinction efficiently reduced conditioned fear responses during extinction training and blocked the recovery of conditioned fear responses, which underscores the influence of the social-learning model.

In our study, participants first acquired a conditioned fear response through classical conditioning. During the extinction stage, both the direct- and the vicarious-extinction groups watched a movie in which the conditioned stimuli were repeatedly presented uncoupled to the shock, but for the vicarious-extinction group, a learning model was also shown in the video watching the conditioned-stimulus presentations. First, we showed that compared with direct extinction, vicarious extinction promoted more extinction and blocked the recovery of fear during a subsequent reinstatement-test stage, during which all subjects were directly exposed to the conditioned stimuli in the absence of the learning model. Second, by adding an additional control group, the vicarious-reinforcement group, we confirmed that the more efficient attenuation of fear could be attributed to the learning model's experience of nonreinforced conditioned-stimulus presentations. Critically, the vicarious-extinction group displayed less reinstatement compared with the vicarious-reinforcement group, which maintained significant CS+/CS- differentiation across reinstatement testing. Thus, in the absence of any differences in directly experienced pairings of conditioned and unconditioned stimuli or in exposure to the learning model, the vicarious-extinction and vicarious-reinforcement groups differed in reinstatement of the conditioned fear response based solely on their observations of the learning model's experience of pairings of conditioned and unconditioned stimuli during extinction. Collectively, these results demonstrate that the presence of the learning model per se during extinction is not sufficient to explain the blockade of reinstatement following vicarious extinction. Rather, the emotional consequences, or the lack thereof, for the model determine the quality of the vicarious-extinction learning.

A subsample (7 of 23) of the participants in the vicarious-extinction group erroneously reported that the model received shocks during the extinction session. Because these participants failed to understand a key aspect of our experimental manipulation, namely the safety of the learning model, they were excluded from the final analysis. Including these participants did not significantly alter the reported group differences. Nevertheless, the fact that this

subsample did not understand (or attend to the fact) that the model did not experience any aversive treatment raises the possibility that although vicarious extinction on average was more effective than direct extinction, the vicarious-extinction procedure may not be effective in all individuals. This potential limitation highlights the notion that understanding the model's experience of safety may be critical to a successful vicarious extinction. It remains to be seen whether this limitation is related to individual differences in the ability to acquire social-safety information in particular or to allocate attention more generally. If the latter is the case, additional care to ensure that attention is directed toward the safety of the model might be sufficient to establish a successful procedure for all participants.

It is noteworthy that vicarious extinction resulted in less expression of conditioned fear during the extinction stage compared with both direct extinction and vicarious reinforcement. On the basis of our results, we cannot exclude the possibility that these differences in extinction performance could help to explain the subsequent differences in reinstatement testing. Arguing against this possibility, however, is that previous research has failed to show a consistent relationship between the decrease in fear responses during exposure/extinction sessions and the subsequent recovery of fears (Craske et al., 2008; Golkar, Bellander, & Öhman, 2013; Prenoveau, Craske, Liao, & Ornitz, 2012). Nonetheless, our data clearly show that vicariously learned safety information both facilitated extinction performance and abolished the return of fear.

Past research suggests that vicarious and directly experienced fear learning draws on partly overlapping neural systems involving the amygdala and that this is reflected in SCRs (Olsson et al., 2007). The same logic can be applied to the interpretation of the current results. Accordingly, vicarious extinction may be dependent on mechanisms partly overlapping with those responsible for the attenuation of learned fears through direct exposure to unreinforced conditioned-stimulus presentations. Previous work on direct extinction suggests that this process is dependent on an interaction between the amygdala and ventro-medial prefrontal cortex (vmPFC; Milad & Quirk, 2012; Phelps et al., 2004). In addition, similar to the vicarious acquisition of fear (Jeon et al., 2010; Olsson et al., 2007), vicarious extinction is likely to depend on the processing of social information, such as the attribution of mental states to other people, involving more dorsal regions of the medial prefrontal cortex (mPFC; Amodio & Frith, 2006; Mitchell, Heatherton, & Macrae, 2002). In our paradigm, watching the calm learning model during extinction might have imbued the CS+ with a safety value resulting in the abolished return of fear during the reinstatement-test stage. It can be speculated that this process involves the top-down impact on the

amygdala by the dorsal mPFC in concert with other prefrontal regions, including the vmPFC, and memory-related regions in the hippocampal complex.

The potency of vicarious extinction in our study is conceptually similar to earlier work in monkeys showing that observing a fearless learning model can cause latent inhibition or “immunization” against subsequent fear learning (Mineka & Cook, 1986). Clinical practice has long benefitted from model-based exposure therapy, which commonly includes the use of an unafraid therapist approaching the feared object (Bandura et al., 1967). Although exposure therapies are efficient in the treatment of phobic fears, a large proportion of patients nevertheless suffer from relapse, during which previously extinguished fears reappear (Craske et al., 2008; Mineka & Zinbarg, 2006). Our findings suggest that model-based learning may help to optimize exposure treatment by attenuating the recovery of learned fears. However, given that the recovery of fear is highly sensitive to both temporal and contextual influences (Bouton, 2004), future research should address the longevity and generalizability of our findings.

To conclude, using a novel design, we demonstrated that the presence of a learning model reduced learned fear during both extinction and reinstatement testing compared with a standard extinction procedure. Critically, we showed that this reduction was dependent on the learning model’s experience of safety. These results have implications for research on both extinction and social-learning processes, and the integration of these in clinical practice.

Author Contributions

A. Golkar and A. Olsson developed the experimental concept. A. Golkar, A. Olsson, I. Selbing, and A. Öhman contributed to the design. Data were collected by I. Selbing and O. Flygare and were analyzed by A. Golkar. A. Golkar and A. Olsson wrote the final manuscript, and all authors approved the final version of the manuscript for submission.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Note

1. The inclusion of these participants in the analyses did not alter the reported group differences.

References

- Amodio, D. M., & Frith, C. D. (2006). Meeting of minds: The medial frontal cortex and social cognition. *Nature Reviews Neuroscience*, 7, 268–277. doi:10.1038/nrn1884
- Askew, C., & Field, A. P. (2008). The vicarious learning pathway to fear 40 years on. *Clinical Psychology Review*, 28, 1249–1265. doi:10.1016/j.cpr.2008.05.003
- Bandura, A., Grusec, J. E., & Menlove, F. L. (1967). Vicarious extinction of avoidance behavior. *Journal of Personality and Social Psychology*, 5, 16–23. doi:10.1037/h0024182
- Bouton, M. E. (1993). Context, time, and memory retrieval in the interference paradigms of Pavlovian learning. *Psychological Bulletin*, 114, 80–99.
- Bouton, M. E. (2004). Context and behavioral processes in extinction. *Learning & Memory*, 11, 485–494.
- Bouton, M. E., Mineka, S., & Barlow, D. H. (2001). A modern learning theory perspective on the etiology of panic disorder. *Psychological Review*, 108, 4–32. doi:10.1037//0033-295x.108.1.4
- Craske, M. G., Kircanski, K., Zelikowsky, M., Mystkowski, J., Chowdhury, N., & Baker, A. (2008). Optimizing inhibitory learning during exposure therapy. *Behaviour Research and Therapy*, 46, 5–27. doi:10.1016/j.brat.2007.10.003
- Gilroy, L. J., Kirkby, K. C., Daniels, B. A., Menzies, R. G., & Montgomery, I. M. (2001). Controlled comparison of computer-aided vicarious exposure versus live exposure in the treatment of spider phobia. *Behavior Therapy*, 31, 733–744.
- Golkar, A., Bellander, M., & Öhman, A. (2013). Temporal properties of fear extinction—Does time matter? *Behavioral Neuroscience*, 127, 59–69.
- Hermans, D., Dirikx, T., Vansteenwegen, D., Baeyens, F., Van den Bergh, O., & Eelen, P. (2005). Reinstatement of fear responses in human aversive conditioning. *Behaviour Research and Therapy*, 43, 533–551. doi:10.1016/j.brat.2004.03.013
- Hill, J. H., Liebert, R. M., & Mott, D. E. W. (1968). Vicarious extinction of avoidance behavior through films: An initial test. *Psychological Reports*, 22, 192.
- Hooker, C. I., Verosky, S. C., Miyakawac, A., Knight, R. T., & D’Esposito, M. (2008). The influence of personality on neural mechanisms of observational fear and reward learning. *Neuropsychologia*, 46, 2709–2724. doi:10.1016/j.neuropsychologia.2008.05.005
- Hygge, S., & Öhman, A. (1978). Modeling processes in acquisition of fears: Vicarious electrodermal conditioning to fear-relevant stimuli. *Journal of Personality and Social Psychology*, 36, 271–279. doi:10.1037//0022-3514.36.3.271
- Jeon, D., Kim, S., Chetana, M., Jo, D., Ruley, H. E., Lin, S. Y., . . . Shin, H. S. (2010). Observational fear learning involves affective pain system and Ca(v)1.2 Ca2+ channels in ACC. *Nature Neuroscience*, 13, 482–488. doi:10.1038/nn.2504
- Kelly, M. M., & Forsyth, J. P. (2009). Associations between emotional avoidance, anxiety sensitivity, and reactions to an

- observational fear challenge procedure. *Behaviour Research and Therapy*, *47*, 331–338. doi:10.1016/j.brat.2009.01.008
- Lamm, C., Batson, C. D., & Decety, J. (2007). The neural substrate of human empathy: Effects of perspective-taking and cognitive appraisal. *Journal of Cognitive Neuroscience*, *19*, 42–58. doi:10.1162/jocn.2007.19.1.42
- Lanzetta, J. T., & Englis, B. G. (1989). Expectations of cooperation and competition and their effects on observers' vicarious emotional responses. *Journal of Personality and Social Psychology*, *56*, 543–554. doi:10.1037/0022-3514.56.4.543
- Lundqvist, D., Flykt, A., & Öhman, A. (1998). *KDEF: The Karolinska Directed Emotional Faces* [CD-ROM]. Stockholm, Sweden: Psychology Section, Department of Clinical Neuroscience, Karolinska Institutet.
- Milad, M. R., & Quirk, G. J. (2012). Fear extinction as a model for translational neuroscience: Ten years of progress. *Annual Review of Psychology*, *63*, 129–151.
- Mineka, S., & Cook, M. (1986). Immunization against the observational conditioning of snake fear in rhesus monkeys. *Journal of Abnormal Psychology*, *95*, 307–318.
- Mineka, S., & Cook, M. (1993). Mechanisms involved in the observational conditioning of fear. *Journal of Experimental Psychology: General*, *122*, 23–38.
- Mineka, S., & Zinbarg, R. (2006). A contemporary learning theory perspective on the etiology of anxiety disorders: It's not what you thought it was. *American Psychologist*, *61*, 10–26. doi:10.1037/0003-066x.61.1.10
- Mitchell, J. P., Heatherton, T. F., & Macrae, C. N. (2002). Distinct neural systems subserve person and object knowledge. *Proceedings of the National Academy of Sciences, USA*, *99*, 15238–15243. doi:10.1073/pnas.232395699
- Myers, K. M., & Davis, M. (2007). Mechanisms of fear extinction. *Molecular Psychiatry*, *12*, 120–150. doi:10.1038/sj.mp.4001939
- Norrholm, S. D., Jovanovic, T., Vervliet, B., Myers, K. M., Davis, M., Rothbaum, B. O., & Duncan, E. J. (2006). Conditioned fear extinction and reinstatement in a human fear-potentiated startle paradigm. *Learning & Memory*, *13*, 681–685. doi:10.1101/lm.393906
- Olsson, A., Nearing, K. I., & Phelps, E. A. (2007). Learning fears by observing others: The neural systems of social fear transmission. *Social Cognitive and Affective Neuroscience*, *2*, 3–11. doi:10.1093/scan/nsm005
- Olsson, A., & Phelps, E. A. (2004). Learned fear of “unseen” faces after Pavlovian, observational, and instructed fear. *Psychological Science*, *15*, 822–828. doi:10.1111/j.0956-7976.2004.00762.x
- Olsson, A., Papenberg, G., McMahon, K., Zaki, J., Bolger, N., & Ochsner, K. N. (2013). *The role of empathy appraisals in vicarious fear learning*. Unpublished manuscript, Department of Clinical Neuroscience, Division of Psychology, Karolinska Institutet, Stockholm, Sweden.
- Olsson, A., & Phelps, E. A. (2007). Social learning of fear. *Nature Neuroscience*, *10*, 1095–1102.
- Phelps, E. A., Delgado, M. R., Nearing, K. I., & LeDoux, J. E. (2004). Extinction learning in humans: Role of the amygdala and vmPFC. *Neuron*, *43*, 897–905.
- Prenoveau, J. M., Craske, M. G., Liao, B., & Ornitz, E. M. (2012). Human fear conditioning and extinction: Timing is everything . . . or is it? *Biological Psychology*, *92*, 59–68. doi:10.1016/j.biopsycho.2012.02.005
- Rescorla, R. A. (2000). Experimental extinction. In R. R. Mowrer & S. B. Klein (Eds.), *Handbook of contemporary learning theories* (pp. 119–154). Mahwah, NJ: Erlbaum.
- Rescorla, R. A., & Heth, C. D. (1975). Reinstatement of fear to an extinguished conditioned stimulus. *Journal of Experimental Psychology: Animal Behavior Processes*, *1*, 88–96.
- Ritter, B. (1968). The group desensitization of children's snake phobias using vicarious and contact desensitization procedures. *Behaviour Research and Therapy*, *6*, 1–6. doi:10.1016/0005-7967(68)90033-8
- Seligman, L. D., & Wuyek, L. A. (2005). Vicarious extinction. In M. Hersen (Ed.), *Encyclopedia of behavior modification and cognitive behavior therapy: Vol. 3: Educational applications* (pp. 1085–1086). Thousand Oaks, CA: Sage.
- Zaki, J., & Ochsner, K. N. (2012). The neuroscience of empathy: Progress, pitfalls and promise. *Nature Neuroscience*, *15*, 675–680. doi:10.1038/nn.3085