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Thinking of attachment figures blocks differential fear conditioning

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Abstract

Thinking of attachment figures can potentially impact acquisition and extinction of fear memories. In this study, 50 participants underwent a fear conditioning and extinction paradigm. Half the participants thought about a supportive attachment figure and half thought about a non-attachment positive experience prior to the fear conditioning. All participants then underwent a differential fear conditioning and fear extinction paradigm, and returned 2 days later for an extinction recall task. Fear-potentiated startle and subjective expectancy of shock ratings were measured as the primary indicators of fear learning across trials. The attachment prime significantly reduced the acquisition of fear-potentiated startle, and this lower level of fear was maintained at the extinction recall task. These results demonstrate that attachment primes can modulate the acquisition of conditioned fear. These findings provide preliminary evidence for the protective nature of attachment relationships at times that are characterized by fear learning.

Key words: attachments; social support; fear conditioning; extinction

Pavlovian fear conditioning is the prevailing model by which fear and anxiety conditions are understood (Johnson *et al.* 2012). Identification of mechanisms that can mitigate fear conditioning and potentially enhance extinction has potential for reducing anxiety disorders such as post-traumatic stress disorder (PTSD) (Parsons and Ressler, 2013). One potential means to ameliorate fear conditioning is via proximity to attachment figures. Bowlby's attachment theory posits that humans have evolved to seek proximity to attachment figures during times of threat because attachment figures typically provide safety (Bowlby, 1969). Much evidence indicates that priming awareness of attachment figures provides a sense of safety and security across a large number of behavioral, cognitive, and neural paradigms (see Mikulincer and Shaver, 2016).

It can be proposed that due to their extensive association with safety, attachment figures become by nature 'appetitive excitors'. According to the Opponent-Process Theory of Motivation (see Dickinson and Dearing, 1979), they would function to inhibit the aversive (fear) system. This proposal could account for empirical evidence consistently showing that activating the attachment system reduces the fear response, at both the neural level (Coan *et al.,* 2006) and physiological level of fear (Bryant and Chan, 2015). Extending these findings is recent evidence that images of social-support figures act as inhibitors, without requiring prior training, insofar as images of an attachment figure, as compared to images of strangers, are not as readily associated with the threat of shock and they inhibit fear responses when paired with a previously conditioned stimulus (Hornstein *et al.,* 2016).

If attachment stimuli were simply safety stimuli or appetitive excitors, then it would be expected to find more fear acquisition acquired to the neutral cues following the removal of the safety

cue, the so-called 'superconditioning' effect (Rescorla, 1971). However, in a subsequent study, Hornstein and Eisenberger (2017) showed that pairing attachment cues with neutral stimuli in a fear-conditioning task result in weaker fear learning than pairing the conditioned cues with images of strangers; further, lower levels of fear to the conditioned stimuli (CS) were maintained even after the attachment cues were removed, suggesting that attachment cues are not simply conditioned inhibitors of the fear response, but function in a distinctive manner.

On the basis of these findings, a model has been proposed in which social supports serve as a 'unique' safety signal that inhibits fear responses (Hornstein and Eisenberger, 2018). They are unique in that they require no prior training and can lead to long-term reductions of fear, unlike conditioned inhibitors. This model notes that to validate this proposal it is important to demonstrate that fear inhibition is achieved by attachment cues to a greater extent than other positively valenced events. This is important because positive stimuli generally may impact fear learning (Raes and De Raedt, 2012; Zbozinek *et al.*, 2015). In this context it is worth noting that Hornstein *et al.* (2016) somewhat addressed this in an experiment that found while participants did not associate fear responses with attachment figures, they were able to experience this association with familiar and rewarding stimuli that were not attachment-related.

To test the proposal that attachments serve as a unique inhibitor of fear, we aimed to compare the fear inhibitory effects of attachment and positive cues. While Hornstein and Eisenberger (2017) found that social support cues resulted in greater inhibition of fear relative to strangers, they did not directly compare the inhibitory effects with positive stimuli. Whereas previous studies of attachments as potential safety signals have paired social cues with the CS, we tested the capacity of a brief awareness of attachment figures prior to fear conditioning to limit fear acquisition. This approach was undertaken because it holds potential applications for understanding how social attachments may moderate acquisition of fear learning in real-world settings in which fear responses are associated with events and responses occurring at the time of threat. Specifically, we examined whether imaginal priming of secure attachment figures or positive stimuli immediately prior to undergoing a differential fear conditioning protocol would impact on the rate of learned fear and the long-term recall of that fear learning, as reflected in self-reported expectancy of shock and fear-potentiated startle. We hypothesized that an attachment prime would reduce the rate of fear learning, which would persist into extinction learning and recall, relative to a non-attachment positive prime.

Method

Participants

Participants were 71 undergraduate psychology students who participated in return for course credit or community paid participants (51 females; mean age = 20.22 years, s.d. = 3.76). They were randomly assigned to the attachment or control conditions. Participants were excluded from participating in the study if they scored in the 'Extremely Severe' range on any of the Depression, Anxiety and Stress Scale (DASS; Lovibond and Lovibond, 1995) subscales or if they reported to have a pre-existing diagnosis of depression, anxiety or a cardiovascular disease. Five participants were excluded for these reasons. A further five participants did not present for the second session of this study, and are excluded from analysis.

Apparatus and materials

Self-report questionnaires. The Experiences in Close Relationships (Revised) questionnaire (ECR-R; Fraley *et al.*, 2000) was used to assess individual differences in attachment style. This questionnaire consists of 36 items that measure attachment anxiety and attachment avoidance. It has good internal consistency of 0.94 and 0.93 for the two subscales of anxiety and avoidance, respectively (Sibley *et al.* 2005). The DASS-21 (Lovibond and Lovibond, 1995) was used to assess negative emotional states. This measure includes 21 items that comprise subscales of depression, anxiety and stress. These subscales have good internal consistencies of 0.94, 0.87 and 0.91, respectively (Antony *et al.,* 1998). The Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) measures an individual's capacity to elicit mental visual images, and was administered to index the comparability of participants' capacities in both prime conditions to imagine the prescribed primes. One item of the VVIQ was altered because it asked participants to visualize a 'relative or friend whom you frequently see'; as this may have elicited an attachment figure, this item was modified to 'think of a person you see often but don't know personally (e.g. a barista at your local cafe)'.

Stimulus delivery. Participants sat approximately 1 m in front of a video display monitor, and were told to pay attention to the screen at all times. Stimuli were presented onto a black screen with a white fixation cross in the center. The visual stimuli used as conditioned stimulus (CS) were squares (black or white), presented in the center of the screen. Auditory stimuli used as the startle probes were 40 ms bursts of white noise measuring at 100 dB, with near instantaneous rise time and presented through binaural headphones. There was a constant background noise set at 65 dB. The stimulus delivery software used was Presentation® (Neurobehavioral Systems, Inc., Berkeley, CA).

Eyeblink startle was measured by recording electromyography (EMG) activity of the orbicularis oculi muscle. Methods followed the suggestions from the Committee Report by Blumenthal *et al.* (2005). Two 4 mm Ag-AgCl electrodes were filled with electrolyte gel and the electrodes were placed approximately 1 cm below the left pupil and below the external canthus. The ground electrode was placed behind the neck. Impedance level was kept below 5 KΩ. The raw EMG was amplified and digitized at 1000 Hz using the ADInstruments Dual Bio Amp (FE135, ADInstruments, Sydney). The signal was then filtered (band-pass = 28–500 Hz), rectified and smoothed with a running average window of 25 ms (LabChart, ADInstruments).

The unconditioned stimulus was a mild electric stimulation delivered to the left forearm of each participant. This was delivered through a stimulating bar electrode with 9 mm disks separated by 30 mm (ADInstruments). The voltage was constant and set at 5 V, with the level of the amperes titrated to each participant from a minimum of 0.3 mA to a maximum of 30 mA, up to the point where it became 'uncomfortable but not yet painful'. The shock involved oscillating current passing through the two disks lasting 500 ms in duration.

At the beginning of each CS trial, the participants were instructed to provide a rating of their expectancy of shock on a 1–10 scale (1 = 'certain no shock', 10 = 'certain shock') using a sliding bar on a response meter (MLT1601/ST, ADInstruments, Sydney). They were told that on each trial they 'may or may not be shocked, at the end of each coloured shape, and if they paid attention to the different coloured shapes, they might be able to predict when the shocks would be delivered'.

Table 1. Participant characteristics

Measure	Attachment		Positive control			
	M	s.d.	M	s.d.	F (1,48)	P
Age	19.7	2.57	20.2	3.76	0.97	0.33
Gender					0.96	0.33
Years of Education	13.8	2.56	15.2	3.25	2.67	0.11
Ethnicity					1.88	0.19
DASS (Depression)	4.96	4.59	3.85	4.33	0.77	0.39
DASS (Anxiety)	4.78	3.5	4.37	4.33	0.13	0.72
DASS (Stress)	7.48	4.91	7.41	4.5	0.003	0.96
VVIQ	3.69	0.62	3.76	0.56	0.19	0.67
ECR (Anxiety)	3.18	0.91	3.21	1.06	0.01	0.92
ECR (Avoidance)	3.51	0.92	3.41	0.89	0.14	0.71

Prime instructions. The mental visualization protocol for the attachment prime asked participants to think of a supportive person that made them feel safe and loved. Participants then answered some questions on their relation to this person, described their personality and typical interaction with them. The control group was required to identify a specific hypothetical situation that would make them very happy, but something that would only involve themselves. They were prompted to modify their choice if it was considered by the experimenter to have a social or attachment-related aspect (see detailed instructions in the Supplementary Table S1). All participants provided ratings on how happy the chosen person/situation made them feel, how excited and their level of closeness with the person/others in the situation on 10-point Likert scales (0 = 'not at all happy/excited/-close', 9 = 'very happy/excited/close'). They were then instructed to vividly imagine the prime for two min with their eyes closed, and finally rated the vividness of the mental image (0 = 'not at all vivid', 9 = 'very vivid').

Procedure

Following written informed consent, participants completed the DASS-21 and VVIQ and then the startle electrodes were attached. The fear learning protocol began with a habituation phase during which nine startle stimuli were presented (Bradley *et al.,* 1993). Then the shock electrodes were attached and the level of the shock was titrated for each participant to a level that was 'uncomfortable but not painful'. This was followed immediately by the fear conditioning protocol that included three phases (adapted from Grillon and Ameli, 2001): preconditioning, involving four presentations of the conditioned stimuli (CS; black or white squares) alone; acquisition, where one of the conditioned stimuli (the CS+) was paired with the unconditioned stimulus (US)(shock) and the other conditioned stimulus (the CS−) was presented alone; and extinction, in which the CS+ and CS− were presented in the absence of the US. The attachment or control prime was administered immediately prior to the acquisition phase. During the acquisition phase, 16 of each stimulus were presented. The CS's were a black and white square that appeared on screen for 8 s. The startle probe (a 40 ms burst of white noise) would occur either 6 or 7 s after the onset of the CS. The shock would co-terminate with a random 10 trials of the CS+, thus providing a partial reinforcement schedule of 62.5%. The inter-trial interval (ITI) was varied with a mean duration of 20 s. A startle probe would occur during half of the ITIs (named startle-alone trials hereafter). Between the acquisition and extinction phases, there was a 5 min rest break. The order of the CS's was presented pseudorandomly with the constraint that no more than four consecutive trials of the same stimulus could occur.

The extinction phase was identical to acquisition with the exception that no shocks were delivered. At the conclusion of session 1, participants were asked which CS predicted shock. They were excluded if they were unable to verbalize the contingencies between the CS's and shock. Data from four participants were excluded for this reason.

Participants returned 2 days later for an extinction recall test. They completed a demographics questionnaire and then electrodes were attached. They were informed that the level of the shock had been set to the same level they had chosen in the first session. Session 2 comprised the same habituation phase followed by an extinction phase as described above. No US was delivered in this session. Participants then completed the ECR-R and were debriefed.

Data reduction

The magnitude of the blink reflex was calculated as the peak value within 21–120 ms following the startle stimulus relative to a baseline, taken as the average EMG response during the 20 ms preceding the onset of the startle probe. Trials on which the baseline was too noisy, with excessive activity during the 20 ms following the probe relative to baseline, were removed (see Grillon and Ameli, 2001; Blumenthal *et al.* 2005). Data from participants who had four or more consecutive missing responses or no detectable startle response were excluded from the analysis, which led to data from seven participants being removed. Differential scores were calculated as the difference between blinks occurring during CS trials compared to blinks during the startle alone trials. For each block of trials, scores were averaged across four trials.

Data analysis

Startle and expectancy data in each phase of the fear conditioning protocol and extinction recall was analyzed via separate repeated measures analyses of variance (ANOVAs). To test the hypothesis that the attachment prime will affect differential fear conditioning, a Group (attachment *vs* positive control) by CS (CS+ *vs* CS−) by block ANOVA was performed. Comparable ANOVAs were conducted for the extinction and extinction recall phases. Any significant interactions were followed-up with simple effects analysis for ease of interpretation.

To assess for a moderation effect of Attachment style, multiple regressions were conducted adding the group variable,

individual's scores on the ECR (attachment anxiety or attachment avoidance) and the interaction of those scores with their group. The dependent variable was the average fear-potentiation startle (FPS; CS+ relative to CS−) during acquisition.

Results

Participant characteristics

After exclusion criteria were applied, 50 participants (40 female; mean age = 20.22 years) were included in the final sample (23 in the attachment group, 27 in the control group). Groups were equally distributed based on gender, age, years of education and ethnicity (see Table 1). There were no group differences on self-reported symptoms of depression, anxiety or stress (as measured on the DASS-21), on ability to engage in visual imagery (as measured on the VVIQ) or levels of attachment anxiety or avoidance (as measured in the ECR) (all P's > 0.05).

Subjective ratings of primes

The Attachment prime was rated by participants as less 'exciting' [$t(1,48) = 7.2, P < 0.01$] than the control prime. The Attachment group rated that they felt closer to others during the prime than the Control group [$t(1,48) = 16.129, P < 0.001$]. Both primes were rated equally in respect to positive valence and vividness of the prime.

Startle

Both groups were equal on baseline startle levels, as indicated by no significant group differences during the startle habituation phase ($P > 0.05$). However, there was lower startle to the CS+ relative to the CS− in the Control group, compared to the Attachment group, during pre-conditioning [Interaction effect of CS x Group: $F(1,48) = 7.817, P = 0.007$]. Simple effect analysis revealed this was driven by a trend toward a significant difference between groups for startle during the CS+ in pre-conditioning [Simple effect (CS+): $F(1,48) = 3.68, P = 0.061$] but not CS− [Simple effect: $F(1,48) = 0.172, P = 0.68$]. Accordingly, startle to CS+ during pre-conditioning was added as a co-variate in all models reported below.

Across the learning trials during acquisition of conditioned fear, there was a significant main effect of CS type, where participants showed larger startle responses to the CS+ than the CS− ($F(1,47) = 22.612, P < 0.001$). Furthermore, this effect was smaller in the Attachment group, showing that the Attachment prime significantly reduced the differential fear response to the CS+ relative to the CS− (Interaction effect of CS x Group: $F(1,47) = 5.151, P = 0.028$). A simple effect analysis follow-up showed that the control group did learn to acquire fear to the CS+ relative to the CS− across conditioning trials (Simple effect (control group): $F(1,25) = 25.183, P < 0.001$), but the attachment group did not (Simple effect (attachment group): $F(1,21) = 3.514, P = 0.075$). This shows that the attachment prime prevented fear acquisition from occurring.

During the extinction phase, there remained a significant differential startle response to the CS+ (Main effect of CS: $F(1,47) = 5.226, P = 0.027$) and a trend toward an effect of a decrease in startle responses across blocks (Main effect of block: $F(1,47) = 3.309, P = 0.075$). There was no interaction effect between groups, meaning that the attachment group did not
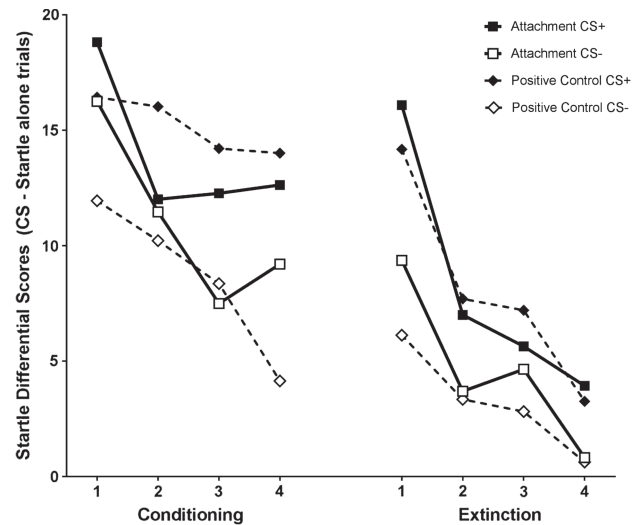

Fig. 1. Fear-potentiated startle (calculated as differential scores subtracted from startle-alone trials) to the CS+ and CS− across blocks of four trials during conditioning and extinction phases.

maintain lower levels of fear responding within the extinction phase (see Figure 1).

During the extinction recall test, there was no significant effect of CS overall (Main effect of CS: $F(1,47) = 1.163, P = 0.286$) and a significant decrease in startle across blocks (Main effect of block: $F(1,47) = 16.084, P < 0.001$), indicating that startle responses completely extinguished to the CS+ (see Figure 2). There was a significant interaction between CS type and group [$F(1,47) = 5.124, P = 0.028$], where fear-potentiated startle to the CS+ relative to the CS− was smaller in the Attachment group. Considering that the attachment group had lower levels of fear acquisition, we followed up this interaction effect by calculating percent recall scores for each individual relative to their respective levels of fear acquisition (percent total fear-potentiated startle within extinction recall relative to conditioning). There was no significant group difference in fear recall scores ($F(1,47) = 1.770, P = 0.190$), indicating that the lower levels of fear within the extinction recall phase were proportional to the initial lower levels of fear acquired in the attachment group.

Subjective expectancies of shock

Participants rated higher average expectancies of shock to the CS+ than the CS− in the acquisition phase (Main effect of CS: $F(1,48) = 428.442, P < 0.001$) and this differential conditioning effect became larger across the blocks (Interaction effect of CS x blocks: linear $F(1,48) = 78.373, P < 0.001$ and quadratic $F(1,48) = 25.794, P < 0.001$). However, the learning rate did not differ between groups. Furthermore, both groups equally showed a greater reduction in their expectancies of shock to the CS+ than the CS− during the extinction phase (Interaction effect of CS x blocks: linear $F(1,48) = 72.443, P < 0.01$; quadratic $F(1,48) = 8.272, P < 0.01$). Also, there were no group differences in the expectancy ratings during the extinction recall phase.

Predictive analyses

Summary tables of regression analyses are presented in Supplementary Table S3. The effect of the attachment prime
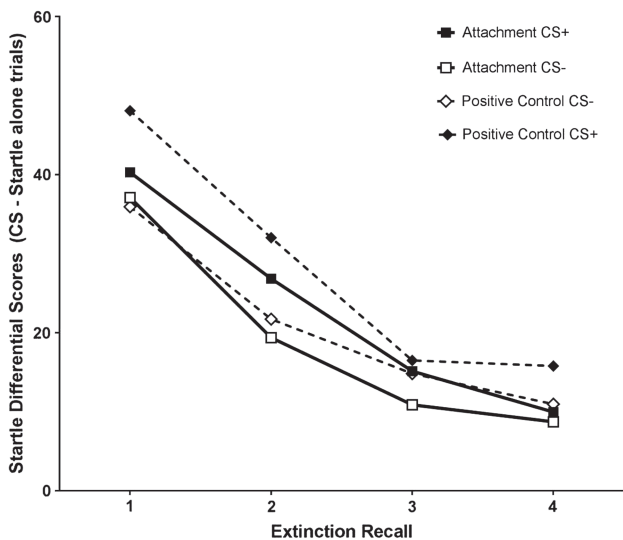
Fig. 2. Fear-potentiated startle to the CS+ and CS− across blocks of four trials during the extinction recall phase in session 2. Note that graphs show adjusted means, corrected for pre-existing differences for startle to the CS+ during pre-conditioning (covariate $\beta = 12.246$).

on the differential fear response averaged across acquisition trials was not mediated by attachment anxiety or avoidance (P's > 0.05). Likewise there were no mediation effects of attachment style during the extinction or extinction recall phases (P's > 0.05).

Discussion

In this study, we explored whether activating an imaginal representation of an individual's attachment figure prior to fear conditioning could slow down their acquisition of fear. The results supported our hypothesis that the attachment prime inhibited the differential fear response during fear acquisition, and this had long-term effects on the recall of extinction 48 h later. These findings replicate an earlier report that social support figures inhibit fear acquisition when attachment figures are associated with the CS (Hornstein and Eisenberger, 2017). This current report extends this previous report by showing that awareness of an attachment figure prior to acquisition, even when the attachment figure is not directly conditioned with the aversive stimulus, limits the extent to which fear is acquired. Moreover, this effect is specific to attachment figures because it was not observed to the same extent as thinking of a positive non-attachment representation. This finding supports one recent model that attachment cues represent unique safety signals that constrain fear learning (Hornstein and Eisenberger, 2018). These results are consistent with evidence that attachment primes inhibit the fear system at neural (Coan *et al.*, 2006), physiological (Bryant and Chan, 2015) and subjective (Ditzen *et al.*, 2008) levels. Prior studies have shown that administration of an anxiolytic drug (LY354740) significantly reduced fear-potentiated startle to threat of shock cues (Grillon *et al.*, 2003). The current finding suggests that imagining an attachment figure can have comparable effects in reducing fear acquisition, and further that the reduction in fear-potentiated startle during acquisition persists for at least 48 h later in the extinction recall test. In short, this pattern of findings indicates that the attachment prime directly

affected the learning during fear conditioning rather than simply inhibiting the startle reflex *per se*.

There was no effect of attachment priming on the subjective rating of expectancy of shock. The dissociation between the subjective and physiological indicators of fear learning has been previously reported (e.g. Hermann *et al.*, 2002). There are multiple memory systems that are modulated by different neural circuitry, such that declarative memories implicate cortical systems and emotional memories can involve limbic, sub-cortical systems (LeDoux, 2003). There is evidence indicating that the amygdala complex is not involved in the short-term memory of declarative knowledge during fear conditioning (Cahill and McGaugh, 1998). It is possible that the attachment prime in the current system differentially impacted emotional and declarative features of the contingency between the stimulus and the US.

We note several methodological issues. First, the positive control and attachment primes were not equated on subjective ratings of excitement. The nature of the positive induction may have resulted in participants providing scenarios that were perceived as more exciting. In the context of evidence that positive emotional states can reduce the fear response (Dickinson and Dearing, 1979; Zbozinek *et al.*, 2015), the current pattern of findings suggests that the attachment prime slowed acquisition of fear over and above the effect of the positive prime. Second, the attachment and positive primes may differ on a range of variables, including vividness, basis on real *vs* imagined scenarios, and other factors. Relatedly, our attachment prime directed participants to think of how the supportive person made them feel safe, and it is possible that the instruction to feel safe served as a safety stimuli rather than the imagining of attachment figures. Future studies should control for these factors in ways that primes differ only on extent to which they direct participants to be aware attachment figures. Third, we recruited participants from a healthy undergraduate sample and accordingly the study population may not include a broader range of attachment styles more commonly seen in clinical populations; future research should replicate this study with participants with more extreme avoidant and anxious attachment tendencies to determine the impact of attachment priming on fear acquisition. Future studies should control for these factors in ways that primes differ only on extent to which they direct participants to be aware of attachment figures. Finally, the small sample size in this experiment could lead to having low power to detect true effects. As such, it would be bordering on impossible to detect any predictive moderation effects of attachment style within such a small sample. A larger-scale replication of this experiment could further investigate the role of attachment styles on the effect of attachment priming on fear acquisition.

These limitations notwithstanding, the current findings replicate and extend prior reports that show how thinking of attachment figures can block associative learning of fear with a neutral cue. This demonstration points to opportunities to modify the acquisition of fear, and potentially to using attachments to modulate how fear memories are managed. This research may have implications for our understanding of how an individual's social attachment systems might modulate how fear-based disorders, such as PTSD, develop and are maintained.

Supplementary material

Supplementary material are available at SCAN online.

Conflict of interest. None declared

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