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There's More to Anxiety Than Meets the Eye: Isolating Threat-Related Attentional Engagement and Disengagement Biases

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Threat-related attentional biases represent a basic survival mechanism. These biases include an engagement bias involving rapid direction of attention toward threat and a disengagement bias involving slow direction of attention away from threat. The exact nature of these biases in healthy and anxious individuals remains controversial because of the challenges associated with accurately isolating each of these attentional biases. Combining a cognitive attentional task with classical conditioning using electric stimulation, we created a new paradigm that makes it possible to more clearly isolate these attentional biases. Utilizing this novel paradigm, we detected both types of attentional bias and differentiated between levels of trait anxiety, in which low- and high-trait anxiety individuals showed equal levels of engagement bias, but only high-trait anxiety individuals showed impaired disengagement from threat.

Keywords: engagement, disengagement, anxiety, attentional bias, cognitive bias

One constant across many different organisms is the provision of mechanisms to perceive and respond to meaningful stimuli in the environment. For example, we humans crucially depend on mechanisms that rapidly direct attention to threatening information and keep our attention focused on a potential threat as long as needed. Because of their clear evolutionary value, it has been argued that these threat-related attentional processes have fundamental survival value (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998). However, when these attentional processes bias our perceptions and responses too strongly, they may be associated with maladaptive patterns that contribute to high levels of trait anxiety and even to anxiety disorders (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzerdoorn, 2007; Mogg & Bradley, 1998; Williams, Watts, MacLeod, & Mathews, 1997).

The two most studied threat-related attentional biases are engagement bias, a rapid orientation of attention to a threatening stimulus that "captures" attention relative to a matched neutral stimulus, and disengagement bias, a delayed withdrawal of attention from a threatening stimulus that "holds" attention relative to a matched neutral stimulus (see Bar-Haim et al., 2007; Cisler & Koster, 2010; Clarke, MacLeod, & Guastella, 2011; Eysenck, Derakshan, Santos, & Calvo, 2007, for reviews). Unfortunately, despite agreement among researchers that engagement and disengagement attentional biases are important to adaptive responding and—when exaggerated—to maladaptive levels of anxiety, there is ongoing debate and uncertainty as to whether one or both of these biases is evident.

Evaluation of Attentional Biases

To appreciate the characteristics of this debate, it is important to first understand how engagement and disengagement attentional biases have been studied. Two canonical experimental paradigms have provided invaluable evidence regarding attentional biases in healthy and clinical populations (see Cisler & Koster, 2010 for a recent review).

The first of these paradigms is the attentional dot probe paradigm (MacLeod, Mathews, & Tata, 1986). In this paradigm, a threatening and a neutral stimulus are simultaneously presented in two locations, followed by a dot that is presented in one of these two locations. The participant's task is to indicate where the dot appears. An attentional bias is assumed when a participant is quicker to respond to a dot that replaces the threatening stimulus relative to a dot that replaces the neutral stimulus. The second of these paradigms is the emotional spatial cuing paradigm (e.g., Fox, Russo, Bowles & Dutton, 2001; Fox, Russo, & Dutton, 2002; Yiend & Mathews, 2001). In this paradigm, a threatening or a neutral cue is shown on the left or right side of the screen, followed by a neutral target that appears either in the same location as the cue (valid trial) or in the opposite location as the cue (invalid trial). An engagement bias is observed via faster responses to valid threat trials relative to valid neutral trials, and a disengagement bias is observed via slower responses to invalid threatening trials relative to invalid neutral trials.

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Key Factors in Disentangling Engagement and Disengagement-Related Biases

As this literature regarding threat-related attentional biases has grown, five methodological factors have emerged as critical to the debate regarding the empirical isolation of the engagement and disengagement biases.

1. A Clear Differentiation Between What Is Considered a Distractor (Emotional in Threat-Related Biases) and the Target (Neutral)

This factor is important because it permits a separate evaluation of attentional biases to threat from those that relate to the target (see Bar-Haim et al., 2007, for a discussion) This factor appears in the attentional dot probe and emotional spatial cuing paradigms in which the threatening stimulus (distractor) is distinct from the dot/square (target).

2. An Emotional Distractor That Is Task Irrelevant

This factor is important because if the distractor is task relevant, attending to the distractor is adaptive. One central manifestation of task relevance is whether the distractor predicts the location of the target. In the attentional dot probe paradigm, although the dot is equally likely to appear in the location of the threatening or the neutral cue, a reasonable strategy to adopt in this paradigm is to try to attend to both locations while expecting the target (see Fox et al., 2001 for a discussion). In the emotional spatial cuing paradigm, in early studies the distractor was task relevant because the valid trial (where the emotional distractor predicts the location of the target) occurred in most trials (see Bar-Haim et al., 2007 for a discussion). In later studies, the proportion of the valid and invalid trials was equated (e.g., Fox, Mathews, Calder & Yiend, 2007), but even in these cases the fact that the distractor appears in the one of two possible locations of the target makes it to some extent task relevant (see Notebaert, Crombez, Van Damme, De Houwer, & Theeuwes, 2011, for a relevant discussion).

3. A Manipulation of the Time Between the Offset of the Emotional Distractor and the Onset of the Neutral Target

This factor is important because it permits examination of temporal components (i.e., engagement and disengagement) of attentional allocation (Bar-Haim et al., 2007). This feature was missing from early versions of the dot probe but it appears in newer versions and is more clearly evident in the emotional spatial cuing paradigm.

4. The Nature of the Emotional Distractor

This feature is important because it has bearing on the origin of any observed attentional bias and on the level of threat that is induced. In most studies using both previous paradigms, the emotional distractor is a symbolic threat such as emotional words or faces. Although these stimulus categories have been widely validated as threat relevant and threat inducing, two possible shortcomings of this approach may be mentioned. First, although emotional words or faces have high external validity, differential attentional biases to these stimuli between anxious and nonanxious individuals can be the result of differential familiarity or past experience with these stimuli (Bar-Haim et al., 2007; McNally, Riemann, & Kim, 1990). Second, although some studies have shown that very harsh looking faces (e.g., Wilson & MacLeod, 2003) or threatening picture scenes (see Mogg & Bradley, 1998 for a review) can induce higher levels of threat, several accounts have suggested that to find early engagement biases one needs to use more potent stimuli that pose real risk for the occurrence of an aversive event (see Koster, Crombez, Verschuere, Van Damme, & De Houwer, 2004; Stormark, Hugdahl, & Posner, 1999). To overcome both of these complications, several emotional spatial cuing tasks have used classical conditioning to pair a novel neutral stimulus with a loud noise or electric stimulation (see Koster et al., 2004; Koster, Crombez, Verschuere, Van Damme, & De Houwer, 2005; Van Damme, Crombez & Notebaert, 2008). However, it is important to state that in these new studies differences between high and low anxious individuals were not reported or not found. Although several theoretical accounts postulate that high intensity threat equally biases attention in everyone (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998), it is unclear whether this null finding is partially due to the complications in separating the engagement and disengagement biases described here. We return to this issue in the *Discussion* when evaluating the results found in this study.

5. The Nature of the Dependent Measure

The type of dependent measure used has a direct effect on the ability to detect and interpret subtle differences in attentional biases. Most previous studies using both paradigms have used reaction times (RTs) as the dependent measure. RTs have been the most common outcome measure in most behavioral tasks that evaluate cognitive functioning (Ratcliff, 1993). Nevertheless, several studies have described complications that relate to using speeded responses when evaluating threat-related attentional biases. In an influential study by Mogg, Holmes, Garner, and Bradley (2008), the presence of an engagement or disengagement bias in the emotional spatial cuing task was highly contingent on whether response slowing was taken into account. Specifically, when response slowing was not considered, a disengagement bias was found among high anxious individuals. However, when response slowing was considered, an engagement bias was found. Therefore, response slowing may arise because threat inhibits motor responses and not necessarily from allocation of attention to threat. Recently, Van Damme et al. (2008) have further developed the rationale for steering away from RTs as the main outcome measure. These authors argue that subtle attentional biases (such as the rapid engagement bias) may be undetected in clinical populations that show motor slowing. Second, RTs effects may reflect influences on decision criteria and not influences on perceptual processing, which are reflected in response accuracy (see Prinzmetal, McCool, & Park, 2005). To overcome these limitations, Van Damme et al. (2008) modified the emotional spatial cuing paradigm by substituting response accuracy for RTs. However, it is important to note that this study did not find either an early engagement bias or a difference between trait anxious and nonanxious individuals.

The Present Study

The goal of the present research was to create and implement a paradigm that more completely isolates engagement and disengagement biases by optimizing the five factors described above. Specifically, in optimization we mean maintaining optimized factors that of prior paradigms together with implementing optimization to the remaining factors. To address this goal, we created an emotional variant of a nonemotional release from capture paradigm (Fukuda & Vogel, 2009, 2011) that evaluated the relationship between individual differences in working memory capacity and between attentional capture (corresponding to engagement bias) and release from capture (corresponding to disengagement bias).

In this paradigm, participants are asked to report the orientation of a Landolt "C" target (i.e., whether the gap of the Landolt C is pointing left, right, up, or down) that is marked with a specific color (e.g., red). The target Landolt C appears simultaneously with three other Landolt Cs that are of different colors (e.g., green, blue, magenta). The four Landolt C stimuli always appear inside four placeholders that remain on the screen throughout the trial. In half of the trials, at varying intervals before the onset of the target, a task-irrelevant colored box distractor appears outside of the placeholders (optimizing factor 1). Although the distractor is clearly task irrelevant (optimizing factor 2) because it appears outside of the possible target locations (i.e., outside the four placeholders) and because there is no response that could be associated with it (i.e., the distractor has no gap and thus cannot point to left, right, up, or down orientation), it is still considered perceptually contingent because it is of the same color of the target.[1] The duration of the interval between the distractor offset and target onset (50, 150, 250, and 350 ms—henceforth distractor-target stimulus onset asynchronies [SOA]) makes it possible to assess with precision release from attentional capture (optimizing factor 3). Specifically, engagement bias in this paradigm is the difference in performance in trials with no distractor (trials in which only the target is presented) versus trials with short distractor-target SOA. In these cases, the contingent distractor captures attention and leads the participant to miss the target that appears soon after. Disengagement bias in this paradigm is the difference in performance in trials with no distractor versus trials with long distractor-target SOA. In these cases, attention is maintained at the contingent distractor, which leads the participant to miss the target.

In the emotional version of the release from capture paradigm (henceforth E-RFC), we created safe and threat blocks. In the safe block, the contingent distractor is emotionally neutral and is in fact identical to the original RFC paradigm. However, in the threat block, we utilized classical conditioning to pair a previously neutral distractor (conditional stimulus [CS]+) with a threat of electric stimulation (unconditional stimulus [US]) (optimizing factor 4). Therefore, the meaning and evaluation of the neutral and emotional distractors is differentiated in the course of classical conditioning, in which one neutral distractor remains neutral throughout the experiment and a second neutral distractor becomes associated with negative emotional consequences (threat of shock). This modification of the task makes it possible to compare engagement and disengagement biases in the threat relative to safe conditions in which any differences found would be above and beyond distractor perceptual contingency, which is identical in both blocks. Finally, our E-RFC paradigm uses performance accuracy rather than response times as the dependent measure (optimizing factor 5).

Using this paradigm, we expected (a) to assess whether the E-RFC paradigm is sensitive enough to reveal engagement and disengagement attentional bias, and, if so, (b) to reveal differing threat-related attentional bias among individuals with high and low levels of trait anxiety. We predicted we would be able to observe a general engagement and disengagement bias. An engagement bias would be manifested by performance accuracy decrements in the threat relative to safe block in trials of short 50-ms distractor-target SOA relative to no distractor trials. The 50-ms distractor-target SOA was chosen as a measure of engagement because it represents a very short interval in which rapid orientation of attention to a stimulus due to its enhanced ability to capture attention can occur but it is unlikely that a disengagement process can be launched (cf. Fukuda & Vogel, 2011). A disengagement bias, which represents delayed withdrawal of attention because of stimulus ability to hold attention, would be manifested by performance accuracy decrements in the threat relative to safe block in long 350-ms distractor-target SOA trials relative to no distractor trials. The 350-ms distractor-target SOA was chosen as our focus because it has been shown that in this paradigm the disengagement process is complete for neutral distractors at this time point indicated in behavioral and electrophysiological indices (cf. Fukuda & Vogel, 2011), making this SOA the appropriate reference point for disengagement bias in the threat block[2] (see a replication in the study presented here).

Regarding trait anxiety, we considered three possible patterns of results. An engagement bias pattern would be evident if, relative to low-anxiety individuals, high-anxiety individuals showed performance decrements in the threat (relative to safe) condition in trials in which there is short distractor-target SOA trials relative to the no-distractor condition. A disengagement bias pattern would be evident if, relative to low-anxiety individuals, high-anxiety individuals showed performance decrements in the threat (relative to safe) condition in the long distractor-target SOA trials relative to the no-distractor condition. A dual engagement and disengagement pattern would be evident if both biases differentiated between low- and high-trait anxiety individuals.

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[1] There is an ongoing debate regarding the attentional mechanism involved in contingent capture and noncontingent capture (i.e., a unique stimulus that does not share any important resemblance to the target). Although several studies have shown that noncontingent distractors can under some circumstances capture attention (e.g., Forster & Lavie, 2008), the (nonemotional) RFC paradigm has shown that using a contingent distractor results in a stronger and more robust attentional capture (Fukuda & Vogel, 2009, 2011).

[2] On the basis of our specific predictions, we utilize a top-down analytical approach that involves examining specific contrasts in two separate ANOVAs: one ANOVA tests the engagement bias with condition (safe, threat) and distractor (no distractor, distractor 50-ms SOA) as within-subject factors, and a second ANOVA tests the disengagement bias with condition (safe, threat) and distractor (no distractor, distractor 350-ms SOA) as within-subject factors. Including the nondistractor condition in the analysis is important because it functions as the reference point for attentional biases in the safe and threat blocks. Specifically, the engagement and disengagement biases are observed when there are decrements in response accuracy for these SOAs relative to the no-distractor condition (see also Fukuda and Vogel, 2011). However, because the no-distractor condition has no SOA values, it cannot be included as a factor in a factorial ANOVA resulting in conducting two separate ANOVAs.

Method

Participants

Thirty-eight undergraduates (16 male; mean age 21.4) from two West Coast universities received either course credit or money ($15) for their participation.

Measures

State and Trait Anxiety Inventory. The State and Trait Anxiety Inventory (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used to assess trait anxiety. This measure includes 20 items (e.g., "I am feeling nervous") on which participants assess themselves using a 4-point likert scale ($1 =$ *not at all*, $4 =$ *all of the time*). In this study we used a median split (which was 38 in our sample) to discriminate between high- ($M = 48.8$, with 11 participants scoring above the clinical cutoff suggested by Fisher and Durham, 1999) and low-trait anxiety individuals ($M = 33.7$, $F(1, 36) = 43.65$, $p < .00001$) The dichotomization of trait anxiety levels is common in prior studies (e.g., Berggren & Derakshan, in press; **13**Fox et al., 2001; Mogg et al., 2008), and the anxiety levels of our high and low groups match those of other studies (e.g., Berggren & Derakshan, in press, with average STAI-T scores for the high-trait anxiety group at $M = 50.47$ and average STAI-T for the low-trait anxiety group at $M = 33.58$) as well as the cutoff values used to differentiate between high- and low-trait anxiety individuals among nonclinical populations (e.g., Eysenck & Byrne, 1991, with STAI-T cutoff for high-trait anxiety at $M > 47$ and STAI-T cutoff for low-trait anxiety at $M < 34$).

E-RFC. In this paradigm (see Figure 1), participants are required to report whether the orientation of a gap in a colored Landolt C (0.8° × 0.8°) is on the top, right, left, or bottom using the arrow keys of the keyboard. The target colored Landolt C (e.g., red Landolt C) can appear in one of four placeholders (1.6° × 1.6°), and it is presented along with three other nontargets that appear in different colors (e.g., blue, green, magenta). Participants are instructed to respond accurately rather than quickly[3] (see Fukuda & Vogel, 2011; Prinzmetal et al., 2005; Van Damme et al., 2008). Each trial begins with a fixation cross together with the four placeholders. On half of the trials, after the fixation cross, a contingent task irrelevant distractor that has no gap and thus no top, right, left, or bottom response that can be associated with it (e.g., a red box 0.8° × 0.8°) appears for 50 ms in a random location outside of the four placeholders. On the other half of the trials, no distractor is presented. On distractor-present trials, there are four possible SOAs between the distractor and the target array: 50, 150, 250, and 350 ms. Each participant performed 8 blocks of 160 trials, with all conditions randomly intermixed within blocks.

The duration of the target array was titrated for each participant in an initial staircasing procedure to find the duration at which performance was 75% correct for the no-distractor condition in each block. To that end, each participant performed 3 blocks of 60 trials before the safe and threat blocks. The target durations for the last 20 trials were averaged to estimate the baseline duration for each block. After each staircase procedure, participants performed 40 trials of practice of the actual task (i.e., trials with no distractor as well as with varying distractor-target SOAs) followed by the actual task.

The E-RFC paradigm includes two types of blocks: safe and threat. The safe and threat conditions are separated by blocks in an effort to minimize the influence of carryover or task-switching effects (e.g., Johnson, 2009) that are more potent in mixed blocks with alternating trials. The structure of each block is identical (i.e., staircase followed by practice and task performance). In the safe block, there was no threat of shock. In the threat block, participants were told that the distractor could be followed by electric stimulation to their wrist. Before performing the threat block, participants were told that the stimulus that appeared outside of the placeholders (i.e., the distractor) could signal electric stimulation but that the target that appears inside of the placeholders is always safe. After the practice phase, the experimenter verified that participants understood which stimulus (i.e., the distractor) signaled threat of shock. In the actual experimental threat block (and in the practice phase of the threat block), a 20-ms electric shock immediately followed the distractor in 20% of the trials in which the distractor appeared. These trials were not analyzed (a random 20% of the same trial types of the safe block were also not analyzed). The color of the Landolt C and of the distractor in safe and threat blocks and the order of the blocks were counterbalanced.

Procedure

After completing a consent form, participants performed a short working memory capacity task that was followed by an administration of a measure of state anxiety. Participants then underwent a customized calibration procedure to determine the intensity of the electric stimulation. An electric stimulator (SD9 stimulator, Grass Technologies, West Warwick, RI.) was used to administer the stimulation via two Ag/AgCl electrodes placed on the left lower arm. Participants adjusted the intensity level so that the shock was unpleasant and required effort to tolerate (cf. Blechert, Michael, Vriends, Margraf, & Wilhelm, 2007). Participants then performed the E-RFC paradigm; completed the STAI-T, which was central for this study, as well as several other background questionnaires;[4] and then were provided with a detailed debriefing.

Results

Preliminary Analyses

We wished to check whether the staircase procedure, which was set to reach a 75% accuracy for the no-distractor condition under the safe and threat blocks, was successful. We found performance to be in the 75% range for the no-distractor condition in the safe block ($M = 74.8\%$, $SE = 0.19$) and in the threat block ($M = 74.6\%$, $SE = 0.16$). Therefore, participants performed at the same level within the threat and safe block when there is no threat in a given trial. This result is important because it demonstrates that

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[3] These task instructions favor an analysis that focuses on accuracy rather than RTs. In addition, the customized staircase procedure (described in the next paragraph) likely further changes the RT distributions. For these reasons we did not analyze and do not report RTs.

[4] The other measures collected were state anxiety, depressive symptomatology, measures of worry and rumination, and an emotion regulation questionnaire. All of the results we report remain essentially unchanged when entering each of these measures as a covariate.

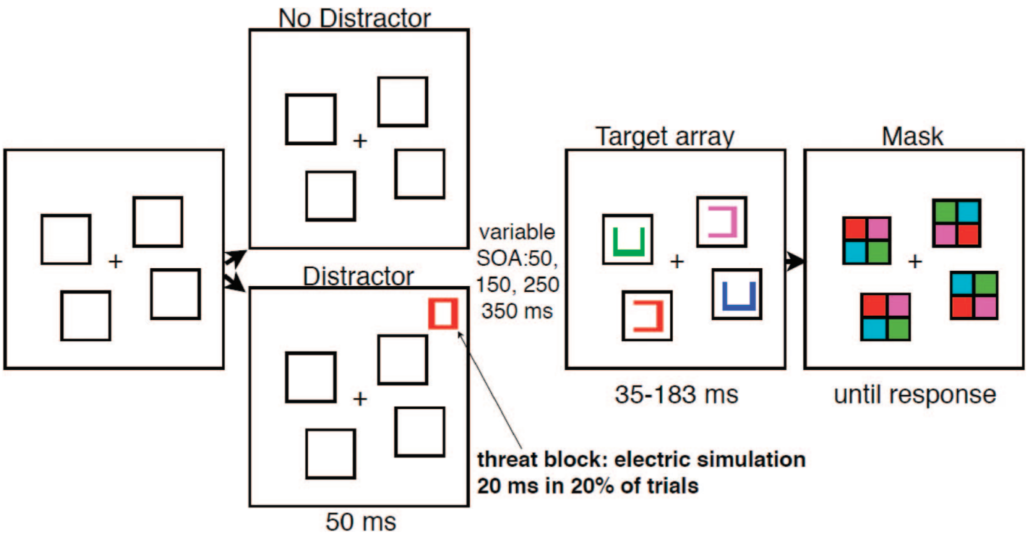

Figure 1. Stimuli and structure of a trial in the E-RFC paradigm. Each trial starts with the presentation of the four placeholders, indicating the possible location of the target. On half of the trials, a distractor box was presented with the same color as the target. On the remaining trials, no distractor stimulus was presented. In the threat block, this distractor was accompanied by a 20-ms electric stimulation (on 20% of the trials when the distractor was presented). The variable SOA between the offset of the distractor and the target array was 50, 150, 250, or 350 ms.

only the distractor was conditioned to the shock and that the target was not contaminated.

In addition, it was also important to establish the 350-ms SOA as a suitable SOA for the evaluation of the disengagement bias. We specifically wanted to replicate the finding from the nonemotional version of our task that found that the nonemotional disengagement process is completed in the 350-ms SOA (Fukuda & Vogel, 2011). To that end, we decided to maintain the 150- and 250-ms SOAs in the E-RFC and to compare their performance to the 350-ms SOA. Indeed, we found that in the safe block relative to the no-distractor condition ($M = 74.9\%$, $SE = .19$), performance in the 150-ms SOA ($M = 69.9\%$, $SE = .2$) and 250-ms SOA ($M = 72.1\%$, $SE = .23$) was significantly worse ($F(1, 37) = 13.216$, $p < .001$ and $F(1, 37) = 4.09$, $p = .05$, respectively), indicating that attention was still at the distractor location when the target appeared, which resulted in decrements in target identification. Therefore, performance in these two SOAs (150 ms, 250 ms) indicates that the disengagement process was not complete. Nevertheless and as expected, performance in the 350-ms SOA ($M = 74.4\%$, $SE = .19$) was similar to performance in the no-distractor condition ($F(1, 37) < 1$), indicating that attention was disengaged from the distractor location, validating it as an adequate reference point in our study to evaluate threat-related disengagement processes.

To assess the psychometric properties of our new task, we computed split-half reliability by first computing the correlations when dividing the data to performance in the first half and second half for each particular condition separately (no distractor, distractor 50-ms SOA, distractor 350-ms SOA under the safe and threat blocks) and then by computing the correlations for first and second half of the engagement and disengagement difference scores. Consistent with limited psychometric properties observed by Schmukle (2005) in nonclinical samples in the dot probe paradigm, which uses difference scores, we found that the psychometric properties of the engagement and disengagement biases in our task were similarly limited: $r(\text{Engagement bias}_{\text{first half}}, \text{Engagement bias}_{\text{second half}}) = .20$, *ns*; $r(\text{Disengagement bias}_{\text{first half}}, \text{Disengagement bias}_{\text{second half}}) = -.10$, *ns*.

Assessing Threat-Related Attentional Biases

Turning to the main analyses, if attention is directed to threatening distractors more rapidly than to neutral distractors, then performance should be reduced in the threat block relative to the safe block in the short distractor-target SOA relative to no-distractor trials. Such a result would suggest that attention was rapidly directed to the distractor while the target appeared. To test for this engagement bias, we conducted a 2 × 2 repeated measure analysis of variance (ANOVA) with condition (safe, threat) and distractor (no distractor, short 50-ms distractor-target SOA) as within-participant factors. This analysis revealed a main effect of distractor, $F(1, 37) = 39.16$, $p < .00001$, $\eta^2 = .07$, partial $\eta^2 = .51$, with accuracy reduced in the short 50-ms distractor-target SOA ($M = 67.83\%$, $SE = 2.47$) relative to the no-distractor condition ($M = 74.76\%$, $SE = 1.5$). It is important to note that this main effect was qualified by the expected condition (safe, threat) by distractor (no distractor, short 50-ms distractor-target SOA) interaction, $F(1, 37) = 5.70$, $p < .03$, $\eta^2 = .009$, partial $\eta^2 = .13$. As can be seen in Figure 2, the drop in performance between the no-distractor and the short 50-ms distractor-target SOA was significantly larger in the threat block ($M_{\text{50ms SOA}} = 65.3\%$, $SE = 2.4$; $M_{\text{no distractor}} = 74.65\%$, $SE = 1.6$) than in the safe block ($M_{\text{50ms SOA}} = 70.3\%$, $SE = 2.1$; $M_{\text{no distractor}} = 74.87\%$, $SE = 1.9$).

If attention is disengaged from threatening distractors more slowly than neutral distractors, then performance should be reduced in the threat block relative to the safe block even in the long

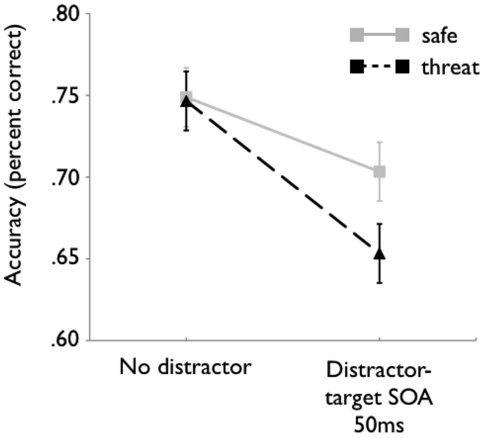

Figure 2. Engagement bias in the E-RFC paradigm. Bars represent confidence intervals.

SOA distractor-target interval (relative to the no-distractor condition). Such a finding would suggest that attention was still at the distractor location long after the distractor's offset. To test for this disengagement bias, we conducted a 2 × 2 repeated measure ANOVA with condition (safe, threat) and distractor (no distractor, long 350-ms distractor-target SOA) as within-participant factors. This analysis revealed a main effect of distractor, $F(1, 37) = 6.90$, $p < .02$, $\eta^2 = .009$, partial $\eta^2 = .16$, with performance reduced in the long 350-ms distractor-target SOA ($M = 72.5\%$, $SE = 1.8$) relative to the no-distractor condition ($M = 74.77\%$, $SE = 1.5$). It is important to note that this main effect was qualified by the expected condition (safe, threat) by distractor (no distractor, long 350-ms distractor-target SOA) interaction, $F(1, 37) = 6.17$, $p < .02$, $\eta^2 = .005$, partial $\eta^2 = .14$. As can be seen in Figure 3, the drop in performance between the no-distractor and the long 350-ms distractor-target SOA was larger in the threat block ($M_{\text{350ms SOA}} = 70.59\%$, $SE = 1.8$; $M_{\text{no distractor}} = 74.65\%$, $SE = 1.6$) than in the safe block ($M_{\text{350ms SOA}} = 74.44\%$, $SE = 2.3$; $M_{\text{no distractor}} = 74.87\%$, $SE = 1.9$). Furthermore, although performance in the safe block was similar under both distractor conditions, $F(1, 37) < 1$, indicating completion of the disengagement process from a neutral distractor (replicating Fukuda & Vogel, 2011), in the threat block performance accuracy was worse in the long 350-ms distractor-target SOA relative to no distraction, $F(1, 37) = 13.33$, $p < .001$, $\eta^2 = .03$, partial $\eta^2 = .26$.[5]

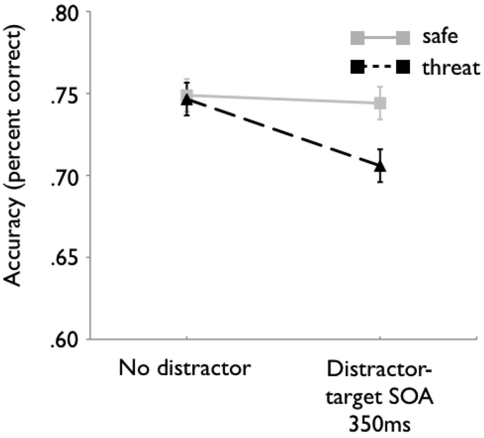

Figure 3. Disengagement bias in the E-RFC paradigm. Bars represent confidence intervals.

We found no correlation between the engagement and disengagement bias ($r = -.23$ *ns*), hinting for a dissociation between the two processes. Nevertheless, this result should be interpreted with caution given the limited psychometric properties of the two biases.

Distinguishing Between Low- and High-Trait Anxiety Individuals

To test whether engagement, disengagement, or both biases best describe differences between individuals with high- versus low-trait anxiety, we performed engagement and disengagement analyses using trait anxiety (low, high) as a between-participants factor.

Analysis of the engagement bias in low- and high-trait anxiety individuals failed to show any differences between groups (all Fs < 1.22, ps $> .27$). However, the fact that the two-way interaction between condition (safe, threat) and distractor (no distractor, short 50-ms distractor-target SOA) was significant, $F(1, 36) = 5.19$, $p < .03$, $\eta^2 = .009$, partial $\eta^2 = .893$, indicates that both groups showed a significant engagement bias to threat; however, this bias was not different for high- versus low-trait anxiety individuals. These findings are inconsistent with an engagement bias and dual attentional bias, both of which predict that high-trait anxiety individuals should show a more rapid engagement with threatening stimuli than low-trait anxiety individuals.

Analysis of the disengagement bias in low- and high-trait anxiety individuals revealed a significant three-way interaction among trait anxiety (low, high), condition (safe, threat blocks), and distractor (no distractor, long 350-ms distractor-target SOA), $F(1, 36) = 6.45$, $p < .02$, $\eta^2 = .005$, partial $\eta^2 = .15$ (see Figure 4). To decompose this significant interaction, we separately examined the two anxiety groups. The simple two-way interaction between condition and distractor was not significant in the low-trait anxiety group, $F(1, 37) < 1$. As can be seen in the left panel of Figure 4, low-trait anxiety individuals did not show any difference in performance between the threat ($M_{\text{350ms SOA}} = 72.61\%$, $SE = 2.4$; $M_{\text{no distractor}} = 73.84\%$, $SE = 2.2$) and safe blocks ($M_{\text{350ms SOA}} = 74.76\%$, $SE = 3.2$; $M_{\text{no distractor}} = 75.48\%$, $SE = 2.6$) when there was a long interval between the distractor and target. This result suggests that low-trait anxiety individuals are able to direct their attention away from threatening distractors when provided with enough time. By contrast, the simple two-way interaction between condition and distractor was significant among high-trait anxiety individuals, $F(1, 36) = 13.44$, $p < .001$, $\eta^2 = .01$, partial $\eta^2 = .27$. As can be seen in the right panel of Figure 4, high-trait anxiety individuals showed impaired performance in the threat condition ($M_{\text{350ms SOA}} = 68.08\%$, $SE = 2.7$; $M_{\text{no distractor}} = 75.66\%$, $SE =$

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[5] Complementary to the disengagement threat bias findings we report for the long 350-ms SOA, we found a clear disengagement bias in the shorter SOAs. Specifically, relative to the no-distractor condition ($M = 74.7\%$, $SE = .16$) the disengagement process was not completed in the 150-ms SOA ($M = 65.6\%$, $SE = .22$) ($F(1,37) = 35.6$, $p < .00001$) or in the 250-ms SOA ($M = 68.8\%$, $SE = .16$) ($F(1,37) = 22.74$, $p < .0001$).

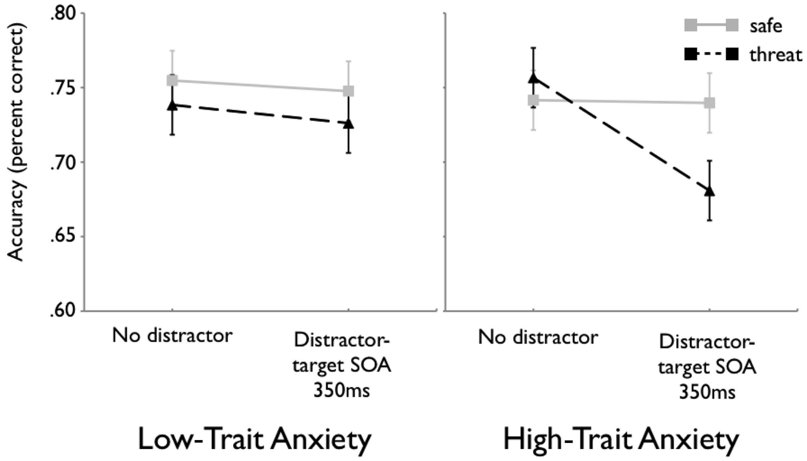

Figure 4. Disengagement bias among high- and low-trait anxiety individuals in the E-RFC paradigm. Bars represent confidence intervals.

2.5) relative to the safe condition ($M_{350\text{ms SOA}} = 73.97\%$, $SE = 3.5$; $M_{\text{no distractor}} = 74.15\%$, $SE = 2.9$) even when there was a long interval between the distractor and the target. This result supports the disengagement bias, which predicts that high-trait anxiety individuals should show slower disengagement relative to low-trait anxiety individuals.

To verify that the differential disengagement profile that we observed between low- and high-trait anxious individuals was not an artifact of the median split we used, we computed a Pearson correlation between continuous trait anxiety levels and the magnitude of the performance decrement under the threat block and found that higher levels of trait anxiety were associated with a stronger disengagement bias, $r = .36$, $p < .03$ (see Figure 5), but not associated with an engagement bias, $r = 0.11$, *ns*.

Discussion

It is widely agreed that threat-related attentional biases constitute a fundamental survival mechanism as well as a risk factor for anxiety disorders when generalized. Nevertheless, the precise nature of these biases has been a matter of dispute over the past several decades. Two canonical experimental paradigms have provided valuable insights regarding the nature of attentional biases in healthy and clinical populations, but it has proven difficult to convincingly isolate engagement from disengagement biases.

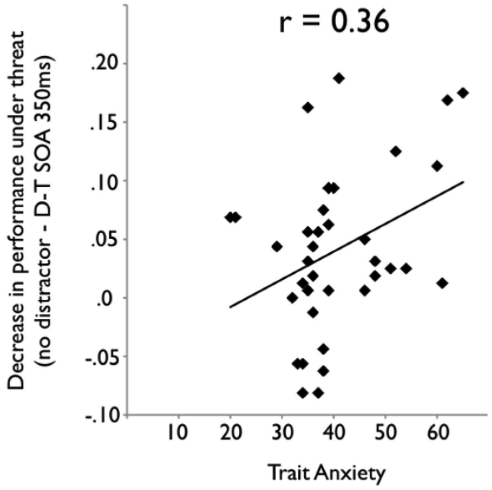

Figure 5. Pearson correlation between continuous trait anxiety scores and the magnitude of the disengagement bias in the threat block.

In the study presented here, we created the E-RFC paradigm to more fully isolate engagement and disengagement biases. Results indicated that this paradigm was sensitive to a rapid attentional engagement bias toward threat and a slow disengagement from it. We also found that although high- and low-trait anxiety individuals showed equal levels of an engagement bias, a differential disengagement bias pattern demonstrated that high- (but not low-) trait anxiety individuals show impaired ability to direct attention away from previously attended threatening information (Fox et al., 2001, 2002; Yiend & Mathews, 2001).

Distinguishing between disengagement biases and engagement biases is challenging. One reason is that the initial engagement of attention toward threat occurs earlier in time and in an early processing stage relative to secondary efforts to disengage attention away from threat. Therefore, finding an engagement bias ensures that this effect is independent from a disengagement bias, but the disengagement bias may be the result of an engagement bias that precedes it. Nevertheless, in the present study, the fact that high- and low-trait anxiety individuals showed comparable early engagement bias rules out the possibility that the later disengagement bias difference derives from a preliminary engagement difference (see also Clarke et al., 2011 for a recent discussion on the necessity of equal engagement bias among low and high anxious individuals in inferring differential disengagement biases).

The results of the present study accord well with an emotion regulation perspective (Cisler & Koster, 2010; Gross, Sheppes, & Urry, 2011; Sheppes & Gross, 2011). According to this account, rapid engagement is the result of automatic processing, and slow disengagement is more related to attentional control abilities and regulatory goals that facilitate strategic processing. From this perspective, attentional biases to threatening stimuli induce rapid and automatic vigilance and engagement that is relatively consistent across individuals. Individual differences emerge later. More specifically, attentional control abilities and effortful strategic regulatory processes that can modulate initial automatic responding are intact in low anxious but may be impaired in high anxious individuals. Although our results seem to be congruent with an emotion regulation perspective, they do not seem to accord with other theories such as the hypervigilance theory (Eysenck, 1992). Specifically, although the hypervigilance theory assumes that high-trait anxiety individuals should show a general breadth of attention that should lead them to enhanced general distractability (Eysenck & Byrne, 1992), we found no performance differences between high- and low-trait anxiety individuals in the safe block. Second, although the hypervigilance theory suggests that high-trait anxiety individuals should show bias in attention (or hypervigilance) toward threat (Eysenck, 1992), we did not find differences between high- and low-trait anxiety individuals in the engagement bias under threat.

The dissociation between engagement and disengagement processes in the context of cognitive attentional capture has also been a major interest in the general field of attention. Recent behavioral and event-related potentials (ERPs) results from the nonemotional RFC paradigm revealed that the cognitive disengagement but not engagement process plays a key role in understanding individual differences in working memory capacity (Fukuda & Vogel, 2011). Our findings also highlight a key role for the emotional disengagement process in understanding individual differences in trait anxiety. Taken together, it appears that general disengagement ability is important across different life domains.

Our findings may have practical therapeutic implications. There is some evidence that specific attentional processes may be improved in anxious individuals using attentional training procedures (e.g., Hakamata et al., 2010; Wadlinger & Isaacowitz, 2011, for recent reviews; however, see Reese, McNally, Najmi, & Amir, 2010 for nonsignificant training findings with specific phobias such as spider phobia). Therefore, understanding the core attentional deficit in anxiety could help customize specific methods of attentional training that would enhance emotion regulation skills and facilitate recovery in anxious individuals. Accordingly, the results of the present study suggest that training procedures that focus on the disengagement bias may offer promise in assisting anxious individuals in overcoming perseveratory attentional processes.

Although the present findings have important theoretical and applied relevance, several limitations of the present study warrant comment.

One general point is that we have identified five key methodological factors relevant to isolating threat-related attentional biases. Although we believe that our E-RFC paradigm makes it possible to more clearly disentangle the engagement and disengagement biases, each factor we have identified should be further evaluated based on its general suitability for a particular research question or the particular goals of a given study. For example, consider differential SOAs between distractor and target to extract engagement and disengagement biases. Although useful, our task may differ from other paradigms in involving a general interference component in which the distraction interferes with the performance of the primary task. To take another example, consider the use of a novel and potent emotional distractor. Although important, the use of personally relevant emotional stimuli may be crucial for some clinical populations that show a very distinct attentional bias such as spider phobics.

A second important limitation and future direction is that we focused on individuals with subclinical levels of anxiety. Although a recent meta-analysis demonstrated that the effect size found for clinical levels of anxiety did not differ from that obtained in subclinical populations (Bar-Haim et al., 2007), future studies should extend our findings by applying the E-RFC paradigm to individuals with clinical levels of anxiety. In doing so, researchers will need to consider how to implement central features of the E-RFC paradigm, such as using electric stimulation (see Blechert et al., 2007, for such implementation). They should also consider the desirability of administering trait anxiety after and not before the experimental procedure. Although this decision enabled us to rule out the influence of priming anxiety characteristics on performance in the E-RFC task, we cannot rule out potential influences of the E-RFC task on relatively stable personality characteristics. A related limitation is that for the main analyses we used a median split to categorize different trait anxiety levels. Although many other studies dichotomized trait anxiety levels, and although we show that continuous levels of trait anxiety correlate with our disengagement threat bias measure, it is possible that other analyses may have been affected by our categorization.

A third limitation relates to the limited psychometric properties found for our task. As in the conventional dot probe (Schmukle, 2005) and spatial cuing paradigms (e.g., Berger, 2006) our task also makes use of difference scores. Given this apparent limitation, alternative bias measures that do not rely heavily on computing difference scores should be suggested.

A final limitation and future direction is that our longest distractor-target SOA interval was 350 ms. We selected this SOA because in the original RFC paradigm this time interval allowed individuals to disengage from contingent neutral distractors (see Fukuda & Vogel, 2009, 2011). Nevertheless, future studies using the E-RFC task should include longer intervals, making it possible to more fully chart the temporal dynamics of attentional disengagement among anxious individuals.

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