Difficulty Disengaging from Threat in Anxiety: Preliminary Evidence for Delayed Response Execution

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Abstract

High anxiety is associated with an attentional bias for threatening information that appears to be the result of difficulty disengaging attention from such stimuli. However, it is yet unknown whether difficulty disengaging, often detected using the probe detection task, results from delayed shifting of visual attention or from interference in executing a behavioral response. The present study tested this distinction by measuring reaction times and eye movements of 30 high trait anxious (HTA) and 28 low trait anxious (LTA) individuals during completion of a probe detection task involving 500 ms presentation of threatening, positive, and neutral images. Difficulty disengaging was detected in the HTA group only for both positive and threatening images. Eye movement results did not show that HTA individuals experience delays in shifting visual attention away from an affective stimulus, thus providing preliminary evidence that difficulty disengaging in the probe detection task is likely a result of delays in decision-making and/or manual response execution.

Keywords: anxiety, attention, threat, eye movements, difficulty disengaging

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Introduction

Cognitive models of anxiety propose that attentional biases in processing threatening information are a primary factor in the etiology and maintenance of anxiety disorders (Eysenck, 1992; Williams, Watts, McLeod, & Matthews, 1997; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998). Such models propose that individuals high in trait anxiety (HTA) display abnormal patterns of attention for threatening information, relative to individuals low in trait anxiety (LTA). Common methods for testing these cognitive models of anxiety include visual probe detection tasks (e.g., MacLeod, Mathews, & Tata, 1986) and eye movement monitoring during presentation of affective stimuli (e.g., Calvo & Avero, 2005). Such research has demonstrated discrepancies between HTA and LTA groups in processing threatening information, including differences in preferential attention and stimulus disengagement (e.g., Koster, Verschuere, Crombez, & Van Damme, 2005; Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005).

Automatic biases for threatening information are a key component of the development and maintenance of anxiety disorders (Eysenck, 1992; Williams et al., 1997; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998) and are driven by a difficulty to disengage attention from threatening stimuli (Fox, Russo, & Dutton, 2002; Koster, Crombez, Verschuere, & De Houwer, 2004; Yiend & Mathews, 2001). Once threatening material is brought into the focus of attention, HTA individuals have difficulty shifting attention away from such material and engaging in alternative tasks (such as coping). Difficulty disengaging has been demonstrated in research using the probe detection (or dot-probe) task, in which presentation of an affective and neutral stimulus pair (i.e., words or images) is followed by the presentation of a neutral probe stimulus (e.g., a dot or an arrow) in the location of one of the previously presented stimuli. The participant’s task is to respond to the neutral probe as soon as it appears. Difficulty disengaging is detected when reaction times on incongruent conditions (i.e., the response probe replaces the neutral rather than affective stimulus) are delayed relative to both congruent conditions (i.e., the response probe replaces the affective stimulus) and neutral conditions (i.e., both stimuli are neutral) (Koster et al., 2004;
Koster et al., 2005). That is, a relative delay in shifting attention from the location of an affective image to the location of the neutral response probe is indicative of difficulty disengaging.

To date, research has not parsed out the specific mechanisms involved in difficulty disengaging. In cognitive tasks that detect difficulty disengaging, participants must shift attention from the affective stimulus to the probe stimulus, and then must make a decision and execute a motor response (i.e., hand movement). We do not yet know whether delayed responding in such tasks results from delays in shifting visual attention from the target location to the probe location, or from subsequent delays in executing the manual response. This distinction has important implications for models of anxiety and approaches to treatment, as delayed attentional shifting results in elaborated processing of threat and maintained anxiety, whereas delayed response execution may be associated with interference in executive processes involving decision-making and motor responsivity.

The present study provides a methodology for examining this distinction by combining reaction time and eye movement monitoring methods, thus obtaining simultaneous measurement of visual disengagement and manual response execution. Eye movement monitoring provides a more direct, ‘first-order’ measure of visual attention which has been used to successfully demonstrate attention biases for affective stimuli in normal and HTA populations (Calvo & Avero, 2005; Nummenmaa, Hyona, & Calvo, 2006; Rohner, 2002). Alternatively, reaction time tasks such as the probe detection task provide ‘second-order’ measures of attention which require a response decision and execution of movement subsequent to attentional shifting. Methodology which pairs eye movement monitoring with the probe detection task permits detection of possible delays in visual shift associated with difficulty disengaging, and thus may highlight potential differences between ‘first-’ and ‘second-order’ measures of attention. The present study is the first to our knowledge to specifically examine the processes underlying difficulty disengaging by measuring eye movements during performance of the probe detection task.

In line with previous research on attention bias in anxiety, we hypothesize that HTA individuals, but not LTA individuals, will demonstrate difficulty disengaging from threatening stimuli, as indicated by significantly longer reaction times on incongruent conditions relative to both congruent and neutral conditions. Additionally, eye movement measures such as the probability of first fixation and total viewing time proportion will confirm this attention bias for threat stimuli in the HTA group. If difficulty disengaging results from delays in shifting visual attention, we expect to see a delay in the execution of saccades to the probe stimulus in HTA versus LTA groups. If difficulty disengaging involves interference in decision-making and response execution processes, we expect to see reaction time delays in the HTA versus LTA groups, but no differences between groups in shifting visual attention to the response probe.

**Method**

**Participants**

Seventy three undergraduate psychology students completed the study for course credit (59 female, 14 male; age $M = 25.1$). Participants were separated into LTA or HTA groups according to their scores on the trait index of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Consistent with previous studies (e.g., Fox et al., 2002; Mogg, Holmes, Garner, & Bradley, 2008; Rohner, 2002), participants with median and near-median scores were excluded ($Mdn = 40$); the resulting LTA group consisted of those scoring 37 or less on the STAI ($n = 28$) and the HTA group consisted of those scoring 43 or greater on the STAI ($n = 30$). All participants reported normal or corrected-to-normal vision.
Materials

Pictorial stimuli.

Image pairs consisted of a target stimulus and a neutral non-target stimulus selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005). Target image categories contained 24 images each and consisted of threatening images (e.g., people attacking, snakes, spiders), positive emotional images (e.g., people engaged in action adventure sports, erotica), neutral images of people (i.e., lacking displayed emotion), and neutral images of objects (e.g., household objects and landscapes)\(^1\). All threat, positive, and neutral images of people depicted people or animals; non-target stimuli always consisted of neutral images of objects and landscapes. The positive emotional images were included to control for arousal level, and were matched with threat images according to IAPS’ normative arousal ratings. Neutral images of people were included in order to control for a possible bias for images of people or faces. Each image pair was randomly presented one time only, making for a total of 96 trials.

Probe detection task.

The present analysis is part of a larger study which included 500 ms and 2000 ms image presentation durations. However, given that there were no group differences in the 2000 ms condition and that difficulty disengaging has been detected only for 500 ms conditions of the probe detection task (Koster et al., 2004; Koster et al., 2005), we limit our focus to the 500 ms condition. Each of the 96 image pairs were presented within a single block (with a break after the first 48 trials), with 48 trials presented within each of the 500 ms and 2000 ms presentation conditions. The 24 image pairs for each of the four image categories (threat, positive emotional, neutral images of people, neutral objects) were randomly assigned to either the 500 ms or 2000 ms presentation condition (always resulting in 12 images per condition for each image category). The 12 images within each presentation duration condition were then further divided into 6 congruent and 6 incongruent trials. (Note that for purposes of counterbalancing and analyzing the neutral object image pairs, one image within each pair was designated as the ‘target’ image and one as the ‘non-target’ image despite both images being selected from the same image category.) Finally, the 6 trials for each congruency condition were further divided into 3 trials in which the target image was presented on the left side of the screen and 3 trials in which the target image was presented on the right side of the screen. Thus, presentation duration (500 ms versus 2000 ms), target stimulus location (right versus left), probe congruency (congruent versus incongruent), and order of presentation of trials were counterbalanced for all participants; and, for each participant, specific image pairs were randomized to each condition using stimulus presentation software (SuperLab 4.0.1; Cedrus Corporation, 2006).

Each trial began with the presentation of a fixation cross displayed for 1000 ms, followed by the presentation of the target-neutral image pair; images measured 16 cm × 12 cm each and were

separated by a 4 cm horizontal distance. Image pairs were immediately replaced by an upward or downward pointing arrow (2 cm in height by 1 cm in width) to indicate participants’ response (on the keyboard number pad, press ‘8’ for up and ‘2’ for down). Reaction times (RTs) were anchored at the presentation onset of the arrow probe stimulus. Following participant response, there was a 1500 ms inter-stimulus interval. The probe detection task was presented on a 48 cm × 30 cm LCD computer monitor with a black background.

**Eye movement monitoring.**

Eye movements (EMs) were monitored via electrooculogram (EOG) recording. EOG is based on a steady difference in electrical potential between the cornea and retina where shifts in eye position ('gaze shifts') are reflected in changes in the magnitude of the EOG signal. In the current study, horizontal EMs were monitored in order to detect attention shifts between images located on the right and left sides of the computer screen (Young & Sheena, 1975). EOG signals were collected using Biopac MP150 electrophysiological recording system and EOG100C amplifier with 4 mm Ag-AgCl electrodes applied at the participants’ external canthi (1.5 cm from the outer edge of each eye) and forehead (ground). Every attempt was made to keep all impedances below 10 kΩ. Data was collected using a DC sampling method at a rate of 200 Hz (one sample every 5 ms; Rohner, 2002). Prior to analysis, EOG data was band-pass filtered from 0.01 to 30 Hz using a Hamming-windowed linear phase FIR filter of order 80,000.

**EOG calibration and measurement.**

In order to calibrate changes in EOG magnitude based on changes in fixation location on the computer screen, participants completed a brief tracking procedure following the probe detection task. Calibration data was used to create a threshold parameter for each individual participant to discriminate between saccades and fixations in the participant’s EOG trace. The parameter was manually chosen so that the smallest EM in the calibration session (fixation point to the inner image edge, 2 cm) and its preceding fixation were correctly detected by the distance filter. This process was based on dispersion techniques for fixation detection (for review see Salvucci & Goldberg, 2000).

EM measurements followed patterns of attentional fixation during presentation of image pairs and response probe stimuli. Individual fixations were defined as shifts in the EOG potential which were larger than the threshold parameter determined by calibration (see above) and which were sustained for at least 50 ms (previous research defines fixations as gaze shifts sustained for a range of 20-200 ms; Miltner, Krieschel, Hecht, Trippe, & Weiss, 2004; Salvucci & Goldberg, 2000). Subsequent to initial movement from the central fixation point (baseline potential), any EOG potential greater than the baseline potential was considered to indicate allocation of attention to the right image, while any EOG potential less than the baseline potential indicated allocation of attention to the left image. The baseline potential was calculated by computing the median EOG potential during the final 500 ms of presentation of the central fixation cross.

Two types of EM measures were collected: fixation location and fixation duration. In effort to assess initial orienting, the probability of first fixation on the target image was calculated by dividing the number of trials in which the individual's first fixation was on the target image by the total number of trials with fixations (Calvo & Avero, 2005). The total duration of all fixations on target and non-target images were calculated for the 500 ms image presentation interval. This fixation duration measure assessed preferential attention for affective information via calculation of viewing time proportion on target images during image presentation [viewing time proportion = time spent viewing target image / (time spent viewing target image + time spent viewing neutral image)]. In order to assess visual disengagement from
affective stimuli, we measured the saccadic reaction time (saccadic RT) to the response probe, defined as the length of time (in ms) between image offset/probe onset and the initiation of the first saccade. Measures of saccadic RT to the response probe were only included for those incongruent trials in which participants were fixating on the target image at the time of image offset/probe onset.

Procedure
Following completion of informed consent procedures, participants were randomly assigned to either complete the STAI questionnaire first or to complete the probe detection task with concurrent EOG measurement first. During the probe detection task, participants were seated 40 cm from the monitor and rested their head on a chinrest in order to minimize movement artifacts.

Data analysis plan
In order to examine interaction and main effects, RT data were subjected to a $4 \times 2 \times 2$ mixed design Analysis of Variance (ANOVA) with image type (threat, positive emotional, neutral images of people, neutral objects) and congruency (congruent, incongruent) as within-subjects variables, and trait anxiety (LTA, HTA) as the between-subjects variable. In order to further investigate difficulty disengaging, planned paired samples t-tests were conducted comparing RTs on incongruent trials against congruent and neutral trials. Neutral RTs were computed by averaging mean RTs for congruent and incongruent conditions of the neutral object image category (Koster et al., 2004), in which 'target' and 'non-target' images were selected from the same image category.

EM measures of probability of first fixation on target image, proportion of viewing time on target image, and saccadic reaction time to image offset/probe onset were each subjected to a $4 \times 2$ (anxiety group) mixed design ANOVA. The sources of significant effects were determined using follow-up t-test contrasts.

Results

Group characteristics
The LTA and HTA anxiety groups differed significantly in trait anxiety (LTA $M = 32.68, SD = 3.48$; HTA $M = 49.80, SD = 4.84$; $t(56) = 15.35, MSE = 1.11, p < .01$), but not in age (LTA $M = 25.71, SD = 8.33$; HTA $M = 23.47, SD = 2.99$; $t(56) = 1.39, MSE = 1.62, ns$) or gender ratios (female: male ratio was 22:6 for the LTA group and 22:8 for the HTA group; $\chi^2(1) = 0.2, ns$). Trait anxiety scores for LTA and HTA groups are comparable with those from previous studies which utilized the STAI to differentiate low and high anxiety groups in order to examine differences in attentional biases (e.g., Koster et al., 2005; Mogg et al., 2008; Rohner, 2002).

Reaction time analysis

Data preparation.

Prior to statistical analysis, trials in which participants made errors in response to the probe stimulus and trials with outlier RTs were removed from the data set (Koster et al., 2004; Koster et al, 2005; Mogg, Bradley, de Bono, & Painter, 1997). The number of errors accounted for 1.5% of the data and ranged from 0 to 8 per participant ($M = 1.46, SD = 1.71$). Outliers (RTs > 3 SDs from individuals’ means) were excluded from analyses and accounted for less than 1% of the data and ranged from 0 to 3 RTs per participant. Consistent with previous studies (e.g., Mogg et al., 1997), two participants (1 HTA, 1 LTA)
were excluded due to outlier mean overall RTs (3 SDs greater than the rest of the sample) and failure to respond on trials. One additional participant’s RT data was lost due to equipment malfunction. Thus, RT analyses included 28 HTA participants and 27 LTA participants.

**Overall effects.**

Contrary to expectations, the 4 (image type) × 2 (anxiety group) × 2 (congruency) mixed design ANOVA for RT failed to reveal a significant interaction between anxiety group, image type, and congruency, \( F(3, 159) = 0.94, MSE = 25.73, p = .42 \), partial \( \eta^2 = .02 \). However, there was a significant main effect of image type on RT, \( F(3, 159) = 6.04, MSE = 17.40, p < .01 \), partial \( \eta^2 = .10 \). Follow up contrasts revealed that this effect was driven by significantly longer RTs for threat (\( M = 669.8 \)) and positive images (\( M = 662.3 \)) than for neutral images of people (\( M = 644.4 \)) and neutral object images (\( M = 649.8 \)). There was also a significant between-subjects effect of anxiety group on RT, as HTA RTs (\( M = 620.2 \)) were significantly faster than LTA RTs (\( M = 693.0 \)), \( F(1, 53) = 4.62, MSE = 23.98, p < .05 \), partial \( \eta^2 = .08 \). No other significant interaction or main effects were detected.

Despite the lack of significant interaction effects, additional planned RT analyses indicated difficulty disengaging in the HTA group (and not the LTA group) for threatening images in the 500 ms presentation condition, which was consistent with predictions. For HTA participants responding to threat images, there were significant differences between incongruent and neutral conditions, \( t(27) = 3.03, MSE = 11.01, p < .01 \), Cohen’s \( d = .57 \), but not between congruent and neutral conditions, \( t(27) = 1.82, MSE = 9.20, p = .08 \), Cohen’s \( d = .34 \). Though the difference between RTs on congruent versus incongruent trials for threat images in the HTA group was not significant, \( t(27) = −1.24, MSE = 13.42, p = .23 \), Cohen’s \( d = .23 \), the direction of results indicated that RTs were quicker on congruent (\( M = 627.4 \)) relative to incongruent (\( M = 644.1 \)) trials, consistent with findings indicating attention bias. In addition, results indicated attention bias and difficulty disengaging in response to positive images in the HTA group [incongruent-neutral: \( t(27) = 2.52, MSE = 9.93, p < .05 \), Cohen’s \( d = .48 \); congruent-neutral: \( t(27) = −.19, MSE = 11.56, p = .85 \), Cohen’s \( d = .04 \); congruent-incongruent: \( t(27) = −2.04, MSE = 13.34, p = .05 \), Cohen’s \( d = .39 \)]. Results did not indicate difficulty disengaging or attention bias for any image category in the LTA group, nor for neutral images of people in the HTA group.

**Eye Movement analysis**

**Data preparation.**

Individual trials were excluded from analyses if one of the following occurred: (1) no saccades or fixations were made during image presentation, (2) the baseline fixation measure was erroneous and did not correspond with those trials immediately preceding or succeeding the trial, (3) the participant shifted his or her gaze away from baseline prior to image onset, and (4) a saccade was made within 150 ms of image onset (minimum saccade latency is about 150 ms; Rayner, 1998). One participant in the HTA group had over half of her trials thrown out based on these criteria; data for this participant was excluded from EM analyses. Equipment malfunction led to the loss of EM data for 10 participants (6 in HTA group, 4 in LTA group). Thus, EM analyses were conducted for 23 HTA participants and 24 LTA participants. In

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\(^2\) An additional 4 x 2 x 2 x 2 mixed design ANOVA which included comparison for presentation duration (500 ms versus 2000 ms) revealed a main effect of presentation duration, \( F(1, 53) = 7.38, MSE = 15.27, p < .01 \), where RTs for the 500 ms condition (\( M = 656.6 \)) were significantly longer than the 2000 ms condition (\( M = 640.2 \)). The main effect for congruency was also significant, \( F(1, 53) = 7.20, MSE = 15.18, p < .05 \), where RTs for the congruent condition (\( M = 643.4 \)) were significantly shorter than the incongruent condition (\( M = 653.4 \)). All other results from this 4 x 2 x 2 x 2 ANOVA were consistent with analyses which excluded the 2000 ms condition: no interaction effects were detected and additional main effects (i.e., image type, anxiety group) were replicated.
this data set, the number of excluded trials accounted for 7.6% of the data and ranged from 0 to 28 per participant ($M = 7.3$, $SD = 7.3$), which is consistent with similar EM research (e.g., Calvo & Avero, 2005; Mogg, Millar, & Bradley, 2000).

**Figure 1**: Mean reaction times comparing congruent, incongruent, and neutral conditions of the probe detection task for HTA and LTA groups in response to threat, positive, and neutral images of people. Differences between incongruent and neutral conditions in the HTA group provide evidence for difficulty disengaging (* indicates $p < .05$). Error bars represent mean standard error. [Note: Congruent and incongruent conditions of the neutral object image category were collapsed to determine neutral RT (e.g., Koster et al., 2004).]

**Overall effects.**

The 4 (image type) × 2 (anxiety group) mixed design ANOVAs for measures of probability of first fixation and total viewing time proportion revealed preferential attention for all images depicting people (including threat, positive, and neutral images of people), but did not reveal a significant influence of anxiety group. Analyses on the probability of first fixation revealed a main effect of image type, $F(3, 135) = 84.75$, $MSE$
= 0.02, p < .001, partial $\eta^2 = .65$, but failed to reveal a significant interaction effect, $F(3, 135) = .41, MSE = 0.02, ns$, partial $\eta^2 = .01$. Subsequent t-test contrasts revealed that the effect of image type was driven by significant differences between all image categories (neutral $M = .50$, positive $M = .69$, threat $M = .73$, threat images of people $M = .80$; all $p$s < .05). Analyses on the proportion of viewing time on the target image during the 500 ms time interval also revealed a main effect of image type, $F(3, 135) = 126.4, MSE = 0.02, p < .001, partial \eta^2 = .74$, but again failed to reveal a significant interaction effect, $F(3, 135) = .98, MSE = 0.02, ns$, partial $\eta^2 = .02$. According to follow up t-test contrasts, the effect of image type was driven by significant differences between all image categories other than the threat-positive contrast (neutral $M = .46$, positive $M = .71$, threat $M = .74$, neutral images of people $M = .86$; all $p$s < .05, excepting the threat-positive contrast). Thus, eye movement results revealed preferential attention for any image depicting a person which did not vary according to anxiety group. Additionally, results indicated that (1) there was a significantly greater likelihood of attending to neutral images of people than to affective images of people (i.e., threat and positive images), and (2) there was a significantly greater likelihood of initially fixating on threat images relative to positive images.

Analysis to test whether difficulty disengaging in the 500 ms condition results from a delay in shifting visual attention or from interference in response processes revealed no significant main or interaction effects of image type or anxiety group on saccadic RT following image offset/probe onset. In fact, saccadic RTs for the HTA group appeared to be quicker ($M = 228.1$) than the LTA group ($M = 252.1$), although this effect did not reach significance, $F(1, 37) = 2.07, MSE = 11.80, ns$, partial $\eta^2 = .05$. Given that difficulty disengaging was detected in RT results for threat and positive images in the HTA group, we conducted additional follow-up analyses to ensure that there were no effects related to delays in shifting of visual attention that may have been obscured in the ANOVA test. First, we conducted follow-up t-test contrasts comparing saccadic RTs for threat ($M = 239.3$) and positive images ($M = 222.3$) with neutral images ($M = 215.5$) within the HTA group specifically. Results confirmed that there were no significant differences indicating delays in shifting visual attention in cases where difficulty disengaging was detected in RT results (that is, for the HTA threat-neutral contrast, $t(20) = 1.45, MSE = 17.20, p = .16, Cohen’s $d = .32$, and for the HTA positive-neutral contrast, $t(19) = 0.53, MSE = 15.53, p = .60, Cohen’s $d = .11$). Second, given that there were a small number of trials for which saccadic RT could be computed for each image type, we computed mean saccadic RTs for both affective image categories (positive and threat) and for both neutral image categories (neutral images of people and neutral images of objects). We then conducted an additional post hoc 2 (image type) × 2 (anxiety group) mixed design ANOVA to determine if saccadic RTs differed according to the presence of difficulty disengaging in the RT results. Results from this analysis also failed to reveal a significant main or interaction effect; however, the main effect of anxiety group nearly reached significance, $F(1, 43) = 3.72, MSE = 11.24, p = .06, partial \eta^2 = .08$, with
the HTA group demonstrating faster saccadic RTs ($M = 218.56$) than the LTA group ($M = 249.26$), which is consistent with a priori analyses. Thus, the current results do not indicate that HTA individuals experience delays in shifting attention from the target image to the response probe.

**Figure 2:** Mean proportion of trials in which participants’ first fixation was allocated to target images (i.e., threat, positive, neutral images of people, neutral images of objects). Analyses revealed that probability of first fixation differed significantly between each of the target image categories, but that the effect of anxiety group (HTA versus LTA) was nonsignificant. Error bars represent mean standard error.

**Figure 3:** Mean proportion of viewing time on target images (i.e., threat, positive, neutral images of people, neutral images of objects) for 500 ms trials. Analyses revealed that proportion of viewing time differed significantly
between each of the target image categories (other than the threat-positive contrast), but that the effect of anxiety group (HTA versus LTA) was nonsignificant. Error bars represent mean standard error.

![Figure 4: Saccadic reaction time in shifting visual attention from threat, positive, neutral-people, and neutral-object images to the response probe for HTA and LTA groups. No significant differences were detected to distinguish HTA and LTA groups. Error bars represent mean standard error.](image)

**Discussion**

The present study utilized concurrent measurement of reaction time (RT) and eye movement (EM) to investigate the mechanisms associated with difficulty disengaging from threatening information in anxiety. Results were consistent with previous research indicating that HTA individuals experience difficulty disengaging from threatening images (Fox, Russo, Bowles, & Dutton, 2001; Fox et al., 2002; Koster et al., 2004; Koster et al., 2005). Interestingly, EM measures did not show that this phenomenon is associated with delays in visual shift, providing preliminary indication that the RT delay that occurs in incongruent trials of the probe detection task may not be due to a delay in shifting visual attention. Instead, the mechanisms associated with difficulty disengaging attention in anxiety, as detected by reaction time tasks requiring manual responses, may be a result of interference occurring during decision-making and manual response execution, rather than resulting from processes associated with visual capture.

This conclusion was further supported by additional discrepancies between RT and EM measures. For example, these two methods revealed different patterns of attention bias for affective information in the two groups, highlighting a distinction between first- (i.e., EM) and second-order (i.e., RT) measures of attentional processing. Although analyses to detect interaction effects in the RT measures failed to reveal significant differences between HTA and LTA groups in patterns of attention bias, RT results did indicate attention bias for positive images and difficulty disengaging from both positive and threat images in the HTA group, while no such biases were detected in the LTA group. Interestingly, this discrepancy between HTA and LTA groups was not evident in EM measures. Instead, the main finding of EM measures highlighted a similarity in the HTA and LTA groups - a bias to initially fixate on motivationally and emotionally salient images. Specifically, analyses of probability of first fixation and total fixation duration revealed that both HTA and LTA groups exhibited a 70-80% likelihood of preferentially attending to threatening, positive, or neutral images of people (as opposed to a near 50% likelihood of attending to neutral target images). As a ‘first-order’ measure of attention, EM results indicated that anxiety does not
influence patterns of visual attention and that both HTA and LTA individuals preferentially attend to both affective and neutral images of people during early stages of processing (i.e., first 500 ms). In sum, the discrepancy between first- and second-order measures of attention further indicates that anxiety does not influence early attentional processing through mechanisms associated with visual capture; rather, anxiety appears to interfere with later processes such as decision-making and/or manual response execution. These findings attributing difficulty disengaging in the HTA group to delays in decision-making and/or manual response execution are consistent with research indicating impaired executive functioning in individuals with HTA (see Eysenck, Payne, & Derakshan, 2005). Such executive deficits may be explained by a behavioral freezing effect in which fear-relevant stimuli elicit an evolutionary-based freeze response (LeDoux, 1996). The freeze response prevents prolonged decision-making or superfluous movement that would be disastrous in the face of a predator. However, such a response is likely maladaptive in modern contexts, as anxiety-related impairment in executive functioning and responsivity would interrupt performance of daily tasks and hinder efforts to achieve personal goals. Future studies may explore the link between anxiety and executive functioning, and may specifically examine whether delayed responding results from impaired decision-making or from impaired motor responsivity.

Interestingly, the HTA group also demonstrated significantly faster overall RTs than the LTA group. While previous research has often shown general RT delays in HTA relative to LTA individuals, some previous studies provide results consistent with these faster RTs. For example, HTA individuals have been quicker to respond on probe detection and spatial cueing tasks, relative to LTA individuals (e.g., Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006). One example of this is the marginally significant main effect of trait anxiety reported in the study by Koster et al. (2006), in which the HTA group demonstrated faster responding than the LTA group across 100 ms and 500 ms stimulus presentation conditions. This effect may reflect enhanced attentional engagement in HTA individuals which results from the rapid allocation of attentional resources following initial threat detection. While the co-occurrence of enhanced attentional engagement and behavioral freezing effects may initially appear paradoxical, it may be the case that enhanced attentional engagement in HTA involves the allocation of processing resources which subsequently delays decision-making and response execution processes. This interpretation may explain why the behavioral freezing effect appears only to apply to HTA individuals’ responses to affective stimuli when compared to their own responses to neutral stimuli. That is, current results indicate that the hypothesized behavioral freezing effect in HTA individuals is not apparent relative to LTA individuals’ performance (i.e., overall RTs were not slower for HTA relative to LTA), which may be due to the lack of enhanced attentional engagement in LTA. Nonetheless, given the potential impact of behavioral freezing on RTs, it is surprising that the HTA group maintained notably quicker RTs, relative to the LTA group. Thus, the explanation that group RT differences are based on facilitated attentional engagement in HTA remains tentative and requires replication in future studies.

Although difficulty disengaging was found in RT data for the HTA group for both threat and positive images (i.e., based on significant differences between neutral and incongruent conditions), the results for a more general ‘attention bias’ (i.e., difference between congruent and incongruent conditions) was found only in response to positive images (and not threat images). This lack of a significant difference in RT results between congruent and incongruent conditions (i.e., lack of a general attentional bias for threatening images) is unexpected given previous studies. One potential reason for this lack of significance is decreased statistical power relative to other RT studies. In our study, participants viewed fewer trials at the 500 ms condition relative to most RT-based studies. This could have contributed to a lack of power, obscuring differences between groups and conditions. However, the pattern of RT results and the size of the effect of attention bias are consistent with previous research in this area (e.g., Koster...
et al., 2004, 2005), suggesting that the reported effects (especially in regards to difficulty disengaging in the HTA group) are in fact genuine. In addition, given the number of trials for which saccadic RTs following target image offset/probe onset could be calculated, current results indicating that difficulty disengaging in anxiety is not related to delays in shifting visual attention is preliminary, and in need of replication.

In terms of the EM findings, the detection of preferential attention (i.e., probability of first fixation, total fixation duration) for all salient information, particularly for positive images and neutral images of people, was unexpected. One interpretation of this finding is that it is consistent with the emotionality hypotheses of attention bias, which argues that biases occur for all emotionally or motivationally salient stimuli (see Nummenmaa et al., 2006). EM research in this area has found that visual attention is significantly more likely to be directed to both positive and negative information, relative to neutral information (Calvo & Lang, 2004; Calvo & Avero, 2005; Nummenmaa et al., 2006). Such findings are in contrast to negativity hypotheses, which posit that attention bias is specific in response to negative stimuli (for discussion, see Nummenmaa et al., 2006). It should be noted that for the present study the difference in probability of first fixation was significantly greater for threat relative to positive images (despite relatively small mean differences), potentially indicating that threat information is more likely to attract attention; however, this conclusion cannot be firmly supported by the present results given that threat and positive images were not presented simultaneously. Current results from EM measures indicating preferential attention (i.e. greater probably of first fixation and proportion of viewing time) for neutral images of people appear inconsistent with predictions that preferential attention is present only for emotional information (e.g., positive emotion and/or threat). However, while the nature of stimuli used in the present study and the relatively low number of trials should be taken into account, it is also important to note that it is difficult to differentiate emotion from people; that is, images of people rated as 'neutral' will still likely draw attention because of their potential emotional salience, including the attentional draw to perceive and recognize emotion. Thus, the current EM results indicating preferential attention for neutral images of people are not entirely incompatible with emotionality hypotheses.

Although the presence of attention bias and difficulty disengaging in response to positive images in the HTA group was also not expected, this finding is also consistent with emotionality hypotheses of attention bias (see Nummenmaa et al., 2006), and again are in contrast to negativity hypotheses. Alternatively, positive images in this study included depiction of action-adventure scenes (such as skydiving and bungee jumping) which may have elicited anxiety reactions in some HTA participants. While such images were necessarily selected in order to obtain images which were equivalently arousing as threat images, the potential presence of an anxiety-inducing effect may explain why the HTA group demonstrated attention bias and difficulty disengaging from positive images. Future studies may wish to avoid use of action adventure scenes in order to avoid such confounds.

The characteristics of the stimuli used in the current study are one potential limitation worth noting. In this study, threatening images included a broad range of threat including depictions of attack to viewer, attack to others, and phobia-specific animals (snakes and spiders). A more powerful comparison might involve individual specific fears (e.g., snake phobia) and presentation of the specific feared stimulus. It should also be noted that the size of images presented in the current study was somewhat larger than images used in previous research. However, the separation between images and distance from the fixation cross to the inside edges of the images was comparable with previous studies (e.g., Koster et al., 2004, 2005, 2006; Rinck & Becker, 2006), thus, shifts in eye movement and spatial attention likely were necessary in order to attend to the primary content of the images (which was generally centered in the middle of the image, 10 cm from the location of the fixation cross). Finally, this study was conducted using a non-clinical sample and did not include a measure of social desirability. Therefore, under-
reporting and/or over-reporting of anxiety symptoms may have obscured differences between the LTA and HTA groups. Nevertheless, our groups differed significantly in their report of trait anxiety and demonstrated different patterns of attention bias/difficulty disengaging in RT results.

The present study is the first to our knowledge to use both RT and EM measures to investigate the mechanisms associated with difficulty disengaging in anxiety. This methodology provides a means for revealing new information about the nature of difficulty disengaging and attention bias in anxiety. The current findings provide preliminary indication that the mechanism responsible for difficulty disengaging attention in anxiety, as detected in probe detection tasks requiring manual responses, impacts processes associated with decision-making and/or manual response execution, and not processes associated with visual capture. The impact of anxiety-related impairment in executive functions involving decision-making and response processing is likely magnified in the context of the real world (as opposed to lab tasks such as the probe detection task) where stimuli are real and decisions are relevant to personal goals. Thus, future research on anxiety-related impairment in decision-making and/or manual response execution will be helpful to inform models of anxiety and related treatment approaches.

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