Does anxiety-linked attentional bias to threatening information reflect bias in the setting of attentional goals, or bias in the execution of attentional goals?

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Abstract

Heightened anxiety vulnerability is characterized by an attentional bias that favors the processing of negative information. However, this anxiety-linked attentional bias is amenable to two quite different explanations. One possibility is that it reflects anxiety-linked bias in the *setting* of attentional goals that favors setting the goal of attending towards negative information over the alternative goal of attending away from such information. Another possibility is that it reflects anxiety-linked bias in the *execution* of attentional goals that enhances the execution of the former attentional goal compared to the latter. The present study introduces a novel methodology designed to discriminate the validity of these competing hypotheses, by examining anxiety-linked attentional bias under two conditions. One condition left attentional goals unconstrained. The other condition imposed the attentional goal of either attending towards more negative or more benign emotional stimuli. The finding that anxiety-linked attentional bias was observed only under the former condition supported the hypothesis that anxiety is characterized by a bias favoring the setting attentional goals involving vigilance rather than avoidance of negative information, while giving no support to the hypothesis that anxiety is characterized by a bias reflecting enhanced execution of the former attentional goal compared to the latter.

Does anxiety-linked attentional bias to threatening information reflect bias in the setting of attentional goals, or bias in the execution of attentional goals?

Cognitive theories of anxiety posit that heightened anxiety vulnerability is characterized by anomalies in attentional selectivity that result in the increased processing of negative information. It is well established that, when stimuli compete for attention, individuals who are high in anxiety vulnerability selectively allocate greater attention towards emotionally negative information relative to non-negative information, compared to individuals low in anxiety vulnerability (cf. Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). To illuminate the basis of this anxiety-linked attentional bias, researchers have sought to identify the mechanisms that underpin heightened attention to negative information. For example, researchers have investigated whether this bias results from strategic or automatic selectivity, with evidence supporting the existence of both automatic and strategic processing mechanisms (cf. Bar-Haim et al., 2007). Researchers have also tested whether anxiety-linked attentional bias to negative information reflects selectivity in attentional engagement or disengagement processes, with research indicating that increased attentional engagement with, and reduced attentional disengagement from, negative information both characterize elevated anxiety vulnerability (Grafton & MacLeod, 2014; Rudaizky, Basanovic, & MacLeod, 2014).

An important distinction that has received less experimental scrutiny concerns the distinction between the *setting* of attentional goals, and the *execution* of attentional goals. Logically, prior to any attentional goal being executed it must be formulated, and so we can distinguish the processes that operate to *set* attentional goals (e.g., the goal of attending to one particular region), from the processes that operate to *execute* these attentional goals (e.g., effectively shifting attention to the intended region). Thus, the processes that influence the setting of attentional goals can be distinguished from the processes that

influence their successful execution. There is clear evidence that the setting of a given attentional goal does not ensure that this goal will always be effectively executed to the same degree. For example, it has been shown that the successful execution of attentional goals that have been set can be influenced not only by task parameters (e.g., Kerzel & Barras, 2015; Theeuwes & Burger, 1998), but also by individual differences (e.g., Fukuda & Vogel, 2011; Whiting, Madden, & Babcock, 2007). This distinction between attentional goal setting and attentional goal execution permits two quite different candidate hypotheses concerning the locus of anxiety-linked attentional bias. Specifically, the anxiety-linked pattern of attentional bias favoring emotionally negative information could result from either an anxiety-linked bias in attentional goal setting, reflecting relative preference in the setting of alternative attentional goals, or an anxiety-linked bias in attentional goal execution, reflecting relative enhancement or impairment in the execution of alternative attentional goals.

Consider now how each hypothesis can account for the common observation that anxious individuals are disproportionately likely to have their attention focused on the locus of emotionally negative information. According to the first hypothesis, highly anxious individuals are disproportionately likely to *set* the goal of attending towards negative information, rather than setting the goal of attending away from negative information. The unbiased execution of their adopted attentional goal then results in anxious individuals showing increased attention to negative information. According to the latter hypothesis, highly anxiety anxious individuals instead display a bias in attentional goal execution, whereby biased efficacy in the execution of set attentional goals results in anxious individuals showing increased attention to negative information.

Further, research motivated by attentional control theory has observed that heightened anxiety vulnerability is characterized by a general reduction in the overall

efficiency of attentional goal execution (Eysenck, Derakshan, Santos, & Calvo, 2007; Eysenck & Derakshan, 2011). Here we suggest that heightened anxiety may differentially impact the execution of alternative attentional goals, with the nature of this bias in goal execution reflecting disproportionate impairment executing the goal of attending away from negative information, and relative enhancement executing the goal of attending towards negative information. Even if equivalent attentional goals are set, such an anxiety-linked bias in attentional goal execution would result in highly anxious individuals showing greater attention to negative information than their less anxious counterparts.

We find it surprising that these alternative possibilities have not been differentiated by previous investigators. Nevertheless, it is clear that the validity of the competing hypotheses concerning the mechanisms that underpin anxiety-linked attentional bias to negative information must be empirically discriminated if we are to fully understand the cognitive basis of this attentional phenomenon. Unfortunately, existing approaches to the assessment of anxiety-linked attentional bias cannot readily distinguish whether this reflects bias in the setting of attentional goals, that favors setting the goal of attentional vigilance for negative information, or bias in the execution of attentional goals, that enhances capacity to successfully execute this particular attentional goal.

One task commonly used to assess anxiety-linked attentional bias to negative information is the emotional-Stroop task. This task requires participants to name the print color of emotionally valenced words while ignoring their semantic content. Relative slowing to color name negative words (e.g. "death") compared to neutral words (e.g. "chair") is taken to indicate an attentional bias to the negative content of these words. Individuals with heightened anxiety vulnerability show greater slowing to color name negative words relative to neutral words, when compared with participants low in anxiety vulnerability (Bradley, Mogg, Millar, & White, 1995; MacLeod & Hagan, 1992; Mogg, Mathews, &

Weinman, 1989). Some investigators have questioned whether anxiety-linked slowing to color name negative relative to neutral words justifies the conclusion that anxious participants selectively attend to negative information specifically, noting the alternative possibility that this effect may reflect anxiety-linked attention to emotional information in general. However, more refined version of the emotional-Stroop that have addressed this issue by comparing performance on negative and positive words have confirmed that heightened anxiety vulnerability is characterized by slowing to color name emotionally negative words, relative to equally emotional positive words (Mathews & MacLeod, 1985; Mogg, Bradley, Williams, & Mathews, 1993). This supports the conclusion that heightened anxiety vulnerability is characterized by an attentional bias to negative information specifically, rather than to emotional information in general.

Given that the emotional-Stroop task instructs participants to attentionally avoid word content, this finding might suggest that high anxious individuals hold a bias that impairs the *execution* of attentional goals to direct attention away from negative information as relative to non-negative information. However, the attentional goal set by the Stroop task instructions does not implicate the emotional tone of the stimulus materials, but instead simply tells participants to assign attention to word color rather than word meaning. Hence such an instruction does not directly challenge the potential goal of attending more to negative semantic information than to benign semantic information. It is possible, therefore, that the observed effect may result from high anxious individuals' displaying an increased likelihood of setting this particular attentional goal. If this is the case, then it would be expected that the expression of anxiety-linked bias on this type of color naming task would remain fully evident, and indeed may increase, if attentional goals were not constrained by instruction in this task. Hence, the anxiety-related effect observed on the conventional emotional-Stroop task can equally well be explained by either of the two

alternative mechanisms we have distinguished, as the conventional use of this task does not permit assessment of anxiety-linked attentional bias both when attentional goals are constrained and when they are left unconstrained.

The attentional probe task is another commonly employed method of demonstrating anxiety-related attentional bias, and this task does not experimentally constrain participants' attentional goals. On each trial, participants initially focus on a central fixation point. Then a pair of differentially valenced stimuli are presented for a short period of time (usually 1000 ms or less) with each member of the pair appearing on opposite sides of the initial fixation point. Immediately after the stimulus pair disappears, a target probe appears in the location where either one of the previous stimuli had been shown. Participants are required to discriminate the identity of the probe as quickly as possible. Selective attention to negative stimuli is revealed by a relative speeding to identify probes in the locus of negative stimuli, relative to probes in the locus of non-negative stimuli. Using this method, MacLeod, Mathews, & Tata (1986) demonstrated that high anxious participants display disproportionate speeding to probes in the locus of negative words relative to neutral words, indicating that they showed an attentional bias toward negative information. Similar effects have also been found in variants of this probe task that use pictorial stimuli rather than words (Bradley, Mogg, White, Groom, & de Bono, 1999; Koster, Crombez, Verschuere, & De Houwer, 2006; Yiend & Mathews, 2001). Again, some investigators have questioned whether anxiety-linked speeding to probes in the location of negative words, relative to probes in the location of neutral words, warrants the conclusion that this anxiety-linked attentional bias is specific to negative information rather than reflecting increased attention to emotional information more generally. Once more, however, refined task variants have directly compared negative and positive stimuli, and have confirmed that individuals with elevated anxiety vulnerability display a relative speeding to discriminate probes in the

location of emotionally negative words, compared to those in the location of equally emotional positive words (Bradley, Mogg, Falla, & Hamilton, 1998; Mogg, Bradley, de Bono, & Painter, 1997; Mogg & Bradley, 1999). Thus findings from the attentional probe task confirm that heightened anxiety vulnerability is characterized by an attentional bias specifically to negative information, rather than to emotional information in general.

Given that this task imposes no constraints on participants' attentional goals, such findings might suggest that high anxious individuals have a bias favoring the *setting* of attentional goals to selectively assign attention to negative information. However, it could be that high and low anxious individuals' adopt identical attentional goals in this task, equally often trying to attentionally avoid or preferentially attend negative information, but high anxious individuals display superior *execution* of the latter attentional goals, resulting in facilitated goal execution when the goal is to attend towards negative information and impaired goal execution when the goal is to attend away from negative information. If so, then it would be anticipated that the expression of anxiety-linked attentional bias would be even greater on the attentional probe task if the task constrained participant's attentional goals, by directing all participants' on each trial to either attend towards or away from the negative member of the stimuli pair. Thus, results obtained to date on the conventional attentional-probe task can be equally well explained by either of the two alternative hypothetical mechanisms we have distinguished as the traditional version of this task does not permit assessment of anxiety-linked attentional bias when attentional goals are left unconstrained and when attentional goals are constrained.

With the aim of discriminating the validity of the competing theoretical possibilities under consideration, the present study will take the novel step of assessing anxiety-linked attentional bias across two variants of the attentional probe task. One variant will measure anxiety-linked biased attention to negative information without experimentally constraining

attentional goals, while the other will do so while experimentally constraining whether participants are required to set the goals of attentionally avoiding negative information or attending towards negative information. If it is the case that anxiety-linked attentional bias to negative information is due to a bias of high trait-anxious individuals, relative to low trait-anxious individuals, favoring the *setting* of attentional goals of attending to negative information, then it would be expected that the task variant which does not experimentally constrain attentional goals, and so permits maximum expression of individual differences in the setting of attentional goals, should reveal the more robust evidence of anxiety-linked attentional bias to negative information. Conversely, if it is the case that anxiety-linked attentional bias is due to high trait-anxious individuals, relative to low trait-anxious individuals, displaying a bias in the *execution* of attentional goals, that enhances execution when the goal is to attend negative information and impairs execution when the goal is to avoid such information, then it would be expected that the task variant which constrains attentional goals via instruction should reveal the more robust evidence of anxiety-linked attentional bias.

Method

Participants

In order to create two groups of participants that differed in level of anxiety vulnerability, a large cohort of undergraduate students ($n = 904$) at the University of Western Australia first were screened on the trait scale of the Spielberger State-Trait Anxiety Inventory (STAI-T). Thirty-six participants were recruited from the bottom third of the resulting STAI-T score distribution (18 male; Age, $M = 18.75$, $SD = 1.80$; STAI-T scores, $M = 29.25$, $SD = 3.32$, range = 21 to 36), and 36 participants were recruited from the top third of this distribution of STAI-T scores (18 male; Age, $M = 18.31$, $SD = 1.74$; STAI-T scores, $M =$

53.69, $SD = 5.59$, range = 45 to 71). These groups were labelled the Low Anxiety Group and the High Anxiety Group respectively.

Materials

Spielberger Trait Anxiety Inventory (STAI-T). The Spielberger Trait Anxiety Inventory is a 20 item questionnaire that provides a measure of trait anxiety. This questionnaire requires participants to indicate how often they “generally feel” each anxiety symptom specified in the inventory (e.g. “I feel nervous and restless”), by selecting one of four options; “almost never”, “sometimes”, “often”, or “almost always”. Scores on the STAI-T range from 20 to 80, with higher scores representing higher levels of trait anxiety. The STAI-T has been shown to have high test-retest reliability and high concurrent and construct validity amongst university student populations (Spielberger & Sydeman, 1994).

Apparatus. The task was run using a PC and a 22-inch widescreen color monitor at a resolution of 1680x1050 pixels with a 15ms refresh rate. Task responses were made using a standard QWERTY keyboard and two button mouse.

Stimulus Images. Our attentional assessment task required a set of 512 images, half of which were emotionally toned representational depictions of real world scenes, and half of which were non-representational abstract images. The 256 representational images were chosen from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008), and were selected based on their standardized ratings on the IAPS affective valence dimension, to create a subset of 128 representational images with a positive emotional valence and a subset of 128 representational images with a negative emotional valence. IAPS images have been normatively rated for emotional valence, on a nine point scale, with higher scores representing more positive images, and lower scores representing more negative images. The mean IAPS valence scores for the 256 IAPS images was 4.79 ($SD = 2.61$). The 128 IAPS images selected for our negatively valenced subset had a mean score of

2.20 (SD = 0.30; Range: 1.51 - 2.71), which was significantly below the neutral midpoint (5.0) of the IAPS valence scale, $t_{(127)} = 106.13$, $p < .001$. The 128 IAPS images selected for our positively valenced subset had a mean scores of 7.37 (SD = 0.40; Range: 6.65 – 8.34), which was significantly above the neutral midpoint score of the IAPS valence scale, $t_{(127)} = 66.61$, $p < .001$. The 256 abstract images consisted of cropped segments of abstract art. An additional set of 32 negative and 32 positive IAPS images together with 64 abstract images was created for use in an initial practice task. No image in the practice set was contained in the image set constructed for use in the attentional assessment.

Attentional assessment task. Our attentional assessment task assessed the degree to which the negative representational images received greater attention than the positive representational images under two conditions. In the “Unconstrained Attention” condition, no instruction was given concerning whether participants should try to attend towards or away from the more negative representational images, thereby permitting maximal opportunity for anxiety-linked differences in the *setting* of attentional goals to exert their influence. In contrast, the “Constrained Attention” condition explicitly directed participants on each trial to attend either towards or away from the more negative representational images, maximizing opportunity for the expression of anxiety-linked differences in the *execution* of these attentional goals.

Unconstrained Attention trials commenced with a fixation cue presented centrally on-screen. When the space-bar was pressed the fixation cue was removed and an image pair was presented, which consisted of one representational image and one abstract image. All stimulus images were presented 85 mm x 85 mm in size on-screen and subtended a visual angle of 8° x 8° at a viewing distance of 60 cm. One image appeared on the left side of the screen, with its right edge 25 mm from center of screen, and the other on the right side of the screen with its left edge 25 mm from center of screen. This subtended a visual angle of

12.82° between the centers of each stimulus image, at the specified viewing distance. The representational image appeared in each locus with equal frequency. After 1000 ms the image pair was removed from the screen and a probe was presented in the location previously occupied by either preceding image with equal probability such that across trials 50% of probes appeared in the locus of abstract images, 25% appeared in the locus of negative images, and 25% appeared in the locus of positive images. The probe comprised two vertically aligned red dots, with the top dot offset slightly to either the left or right of the bottom dot. Participants were required to indicate the identity of the probe by pressing the left mouse button if the top dot was offset to the left of the lower dot, or the right mouse button if the top dot was offset to the right of the lower dot. After a correct response the screen was cleared and the next trial commenced after a 1000 ms delay. After an incorrect response, participants were informed via an on-screen message that their response was incorrect, and the next trial commenced after a 1000 ms delay.

Trials in the Constrained Attention condition were identical to those in the Unconstrained Attention condition, in terms of virtually all parameters. The same image pairs were exposed in the same screen positions and, as in the Unconstrained Attention condition, the representational member of image pairs appeared in each locus with equal frequency, and across trials 50% of probes appeared in the locus of abstract images, 25% appeared in the locus of negative images, and 25% appeared in the locus of positive images. However, the Constrained Attention condition now set participants an attentional goal on each trial, which either involved attentionally favouring negative images more than positive images, or attentional favouring positive more than negative images. Specifically, each trial commenced with a centrally positioned attentional instruction rather than a fixation cue. One type of instruction set the goal of attending towards negative representational images more

than positive representational images, by telling participants to direct attention to the representational image (rather than abstract image) if it is negative and to direct attention away from the representational image (towards the abstract image) if it is positive. The other type of instruction set the goal of attending away from negative representational images more than positive representational images, by telling participants to direct attention away from the representational image (towards the abstract image) if it is negative, and to direct attention towards the representational image (rather than abstract image) if it is positive¹. These two types of attentional instructions, which we will term “attend negative” and “avoid negative” respectively, occurred with equal frequency. Participants took as long as they required to process this instruction, in order to set the appropriate attentional goal, before then pressing the spacebar to initiate the trial that required them to execute this particular attentional goal.

Importantly, it should be noted that the presence of any particular instruction did not predict the emotional tone of the presented representational image. Moreover, the probability of the probe being in the locus of the representational or abstract image also was not predicted by instruction type, with half the probes still appearing in the locus of the abstract images and half in the locus of the representational image. Therefore, in this Constrained Attention condition, as in the Unconstrained Attention condition, there was no contingency between image type and probe position. However, to encourage good compliance with the attentional goal set by the specific instruction, the target probe was presented in the locus that participants had been instructed to attend to on 75% of trials. On the remaining 25% of trials the target probe was presented in the opposite locus, thereby permitting computation

¹ The instructions as presented on screen were, “ATT NEG” (meaning attend to the representational image if it is negative), “AVD NEG” (meaning avoid the representational image if it is negative), “ATT POS” (meaning attend to the representational image if it is positive), and “AVD POS” (meaning avoid the representational image if it is positive).

of the degree to which discrimination latency was speeded for probes appearing in the location of the stimulus that participants were endeavoring to attend to, compared to probes appearing the location of the stimulus they were endeavoring to attentionally avoid.

The experimental task contained 256 trials. Half of the trials were delivered in the Unconstrained Attention condition and half were delivered in the Constrained Attention condition. These two types of trial were presented in alternating blocks of 64 trials. The order of blocks was counterbalanced across participants. After every 32 trials participants were given a self-timed rest period. An overview of trial timing, task conditions, and example trials is presented in Figure 1.

[Figure 1]

As probe discrimination latencies were used to compute our index of attentional bias to negative images it was important to ensure that participants were accurate in discriminating probe identity. Consequently, participant inclusion required maintaining a high level of accuracy, set at 90%. Probe discrimination latencies were filtered to exclude outlying reaction times using the exclusion approach commonly adopted by previous researchers (cf. Bradley et al., 1999; Clarke, Browning, Hammond, Notebaert, & Macleod, 2014; Mogg et al., 1997) which involved eliminating latencies that fell more than 1.96 standard deviations from a participant's mean latency for that trial condition, or that exceeded 2000 ms. Following this, using latencies to correctly discriminate probe identity an Attentional Bias to Negative Images Index was computed from trials in the Unconstrained Attention condition and from trials of each instruction type in the Constrained Attention condition. The Attentional Bias to Negative Images Index expressed the degree to which discrimination latencies for probes that appeared in the locus of the representational image

were disproportionately speeded relative to probes that appeared in the locus of the abstract image, when the representational image was negative rather than positive in emotional valence. Formally, the equation used to calculate the Attentional Bias to Negative Images Index can be expressed as:

$$[(RIN;PDRI) - (RIN;PPRI)] - [(RIP;PDRI) - (RIP;PPRI)]$$

Where RIN = "Representational Image Negative", RIP = "Representational Image Positive", PDRI = "Probe Distal to Representational Image", and PPRI = "Probe Proximal to Representational Image". Increasing positive values on this index score represent relatively greater attention towards negative compared to positive representational images, whereas increasing negative values on this index score instead represent greater attentional avoidance of negative compared to positive representational images.

Procedure

Upon arrival participants were provided with an information sheet and consent form. Once written consent was obtained, participants completed the STAI-T questionnaire, then were seated in front of the computer, at a viewing distance of 60 cm, and were informed of the task requirements. Participants were told that probes would appear with equal probability in either image location on trials that give no attentional instruction, but that probes would most often appear in the location they had been instructed to attend to on trials which give an attentional instruction. Participants were told to identify the orientation of each probe by pressing the appropriate response button as quickly and as accurately as possible. The experimental task was preceded by a shortened practice version of the task, comprising 64 trials which exposed participants to all possible conditions. Participants then completed the experimental task, and were subsequently debriefed.

Results

Two participants failed to meet the 90% accuracy requirement and so were excluded prior to any subsequent analysis. Mean accuracy of remaining participants was reassuringly high, at 97.46% ($SD = 1.77$, range = 91.4% – 100%).

Figure 2 presents the Attentional Bias to Negative Information Index scores obtained in the Unconstrained Attention condition. In order to determine if anxiety-linked negative attentional bias was evident when attention was left unconstrained in this manner, a one-way ANOVA was carried out on these data, which considered Trait Anxiety Group (high trait anxious, low trait anxious) as the between-groups factor.

[Figure 2]

This analysis revealed a significant effect of Trait Anxiety Group, $F(1, 68) = 4.72$, $p = .033$, $\eta^2 = .065$, reflecting the fact that Attentional Bias to Negative Images Index scores were elevated in the high anxiety group ($M = 28$, $SD = 218$) compared to the low anxiety group ($M = -83$, $SD = 210$). Thus, an anxiety-linked attentional bias, favoring the setting of attentional goals to attend towards negative relative to positive information in the high anxiety group compared to the low anxiety group, was evident when attention was left unconstrained in order to permit ready expression of individual differences in the degree to which participants' set attentional goals to attend to negative information. We also turned to assess whether each anxiety group showed an attentional bias for negative information that was nominally different from zero. Attentional Bias to Negative Images Index scores within the low anxiety group were significantly different from zero, $t(69) = -2.34$, $p = .025$, whereas scores within the high anxiety group were not, $t(69) = 0.76$, $p = .45$. This pattern of results endorses the initial finding that high anxious individuals displayed relatively greater

attentional bias to negative information, compared to low anxious individuals, when attention was left unconstrained.

Figure 3 presents the Attentional Bias to Negative Images Index scores obtained under the Constrained Attention condition. In order to determine if anxiety-linked negative attentional bias was evident when attentional goals were imposed, a 2 x 2 mixed design ANOVA was carried out on these data. The repeated measure factor was Direction of Attentional Constraint (attend negative, avoid negative) and the between-groups factor was Trait Anxiety Group (high trait anxiety, low trait anxiety).

[Figure 3]

This ANOVA revealed a significant main effect of Direction of Attentional Constraint, $F(1, 68) = 245.57, p < .001, \eta^2 = .78$, due to the fact that Attentional Bias to Negative Images Index scores were higher in the attend negative condition ($M = 411, SD = 225$), than in the avoid negative condition ($M = -455, SD = 256$). This effect confirms that participants sought to, and were able to, comply with attentional instructions across the task. Further evidence that this was the case comes from the fact that in the attend negative condition Attentional Bias to Negative Images Index scores were significantly greater than zero, $t(69) = 15.27, p < .001$, indicating that participants selectively attended towards the negative images more than the positive images when instructed to do so. Conversely, in the avoid negative condition, Attentional Bias to Negative Images Index scores were significantly below zero, $t(69) = -14.85, p < .001$, indicating that participants selectively attended away from the negative images more than the positive images when instructed to do so.

Crucially, however, there was no impact of Trait Anxiety Group as either a main effect, $F(1, 68) = .35, p = .56$, or within an interaction involving Direction of Attentional Constraint

and Trait Anxiety Group $F(1, 68) = .69, p = .41$. As can be seen from Figure 3, high trait anxious participants demonstrated no significantly greater execution of attentional goals than did low anxious participants to selectively attend toward negative information when directed to do so, and no significantly reduced execution attentional goals to attend away from negative information when directed to do so. Thus, these results provide no evidence whatsoever of anxiety-linked attentional bias when attention was constrained, which is the condition that should be maximally sensitive to individual differences in participants' relative *abilities* to selectively shift attention towards or away from negative information.

Spearman's Rho correlations provided further evidence that variation in trait anxiety was related to attentional bias towards negative images only in the Unconstrained Attention condition. Specifically the correlation between Attentional Bias to Negative Images Index scores and STAI-T trait anxiety scores was significant in the Unconstrained Attention condition, $r_s(68) = .37, p < .01$. In contrast, the correlation between Attentional Bias to Negative Images Index scores and STAI-T trait anxiety scores did not approach significance in the Constrained Attention condition, either when the instruction directed participants to attend to negative images $r_s(68) = .12, p = .33$, or to avoid negative images, $r_s(68) = .003, p = .98$. This reinforces the conclusion that anxiety-linked attentional bias to negative information was evident only on the task variant designed to be maximally sensitive to individual differences in the setting of attentional goals, and not on the task variant designed to be maximally sensitive to individual differences in the execution of attentional goals.

Finally, we conducted an exploratory analysis on the time intervals observed in the Constrained Attentional condition trials, between participants receiving the initial instruction that specified the attentional goal, and pressing the spacebar to receive the image pair followed by the probe. These latency data were subjected to a two way ANOVA

that considered the within group factor Attentional Goal Type (attend negative, avoid negative), and the between group factor Trait Anxiety Group (high trait anxious, low trait anxious). No significant effects emerged from this analysis indicating that the type of attentional goal did not affect the speed at which participants initiated the onset of image pairs across trials.

Discussion

The aim of the current study was to empirically discriminate the validity of two differing hypotheses concerning the mechanism that underpins anxiety-linked attentional bias to negative information. One hypothesis under investigation was that this attentional bias reflects an anxiety-linked bias in the *setting* of attentional goals that operates to favor setting the goal of attending towards negative information over the goal of attending away from negative information. The other hypothesis was that this bias instead reflects an anxiety-linked bias in the *execution* of attentional goals that serves to enhance execution of goal-consistent attentional shifts when the participants adopt the goal of attending towards rather than away from negative information.

In the present study high trait anxious participants exhibited greater attention to negative information, relative to positive information, than was displayed by low trait anxious participants, but only under the task condition that did not constrain their attentional goals, and so permitted maximum influence of individual differences in the *setting* of attentional goals. In contrast, high trait anxious individuals did not exhibit greater attention to negative information relative to positive information, than was shown by low trait anxious participants, under the task condition that served to set a specific attentional goal on each trial, and assessed for individual differences in the *execution* of the attentional goals of attending towards or away from negative information. Moreover correlational analysis confirmed that variation in trait anxiety was associated with variation in attentional

bias only in the former task condition. This pattern of results supports the hypothesis that anxiety-linked attentional bias to negative information reflects a bias that favors setting the attentional goals of attending towards rather than away from negative information, rather than reflecting a bias involving relative enhancement in the execution of execution of the former attentional goal compared to the latter. It is interesting to note that in our particular participant sample, although low anxious participants clearly displayed an attentional bias avoiding negative information, high anxious individuals although displaying significantly greater attentional bias for negative information did not display levels of attentional bias that were greater than zero. It is possible that had we recruited individuals who were more highly anxious we may have observed even greater levels of attentional bias for negative information. Thus, it is difficult to infer what this informs us about the precise attentional goals that were set by high anxious individuals. Importantly however, the nature of the relative discrepancy between the two anxiety groups support the hypothesis that individuals higher in anxiety vulnerability set attentional goals that favor attention to negative information to a comparatively greater degree than individuals who are relatively lower in anxiety vulnerability.

The findings of the present study extend theoretical understanding of anxiety-linked attentional bias. Although previous research has established that individuals are ultimately able to acquire the ability to display bias in attentional processing that favors, or does not favor, attention to negative information after a period of attentional training (Bar-Haim et al., 2010; Krebs et al., 2010; Nishiguchi et al., 2015), the present study has illuminated the novel question of whether high anxious individuals, compared to low anxious individuals, differ in the degree to which they are spontaneously able to comply with instructions that necessitate the display of such biases. This finding carries potential implications for current and future methodological approaches to the measurement of anxiety-linked attentional

biases. Furthermore, they provide information that may bear upon the design of intervention approaches that aim to therapeutically attenuate heightened anxiety vulnerability by changing dysfunctional patterns of attentional selectivity. These implications will be considered in turn.

Previous investigators seeking to illuminate the basis of anxiety-linked attentional bias have not typically distinguished the component processes of attentional goal setting and attentional goal execution. The results of the present study demonstrate the importance of this distinction, and advance theoretical understanding by indicating that the individual differences in anxiety that underpin heightened attention to negative information relate to selectivity in attentional goal setting. Although prior theories have been largely silent with respect to this issue, some existing models invite the inference that heightened anxiety may instead have been found to be associated with the impaired execution of attentional goals that involve attending away from negative information. For example, in their theory of selective processing in anxiety Mathews and Mackintosh (1998) posit that when the “threat evaluation system” classifies information as sufficiently negative then such information captures attention, with the consequence that alternative attentional goals are disrupted. They attribute anxiety-linked bias to the heightened sensitivity of this threat evaluation system. Similarly, Bar-Haim et al. (2007) contend that heightened anxiety is associated with the increased sensitivity of an evaluation system that assesses the strength of threatening information. When this system classifies information as strongly threatening, which is more likely for anxious individuals, then the allocation of attention to this negative information overrides alternative attentional goals. Such theoretical accounts readily permit the possibility that heightened anxiety may compromise the effective execution of attentional goals that involve avoidance of negative information. However, because these prior models do not differentiate between attentional goal setting and attentional goal

execution, they also permit the possibility that oversensitivity of the threat evaluation system in anxious individuals may disrupt or override the *setting* of attentional goals that involve such avoidance of negative information, rather than disrupt or override the *execution* of such attentional goals. By introducing this conceptual distinction and providing evidence that heightened anxiety is characterized by bias in the setting, rather than in the execution, of attentional goals, the present study can contribute to the refinement of these existing models in ways that increase their precision.

Of course, there are important questions that remain to be answered concerning the cognitive mechanisms that underpin the anxiety-linked differences in attentional goal setting revealed by the present study. One question concerns whether the anxiety-linked differences in attentional goal setting that operated within the Unconstrained Attention condition involved the goal of increased attentional engagement with negative information or decreased attentional disengagement from negative information. Recent evidence suggests that both forms of attentional selectivity are implicated in anxiety-linked attentional bias (Grafton & MacLeod, 2014; Rudaizky et al., 2014), and so it seems plausible that both types of biased goal setting will operate. Future extensions of the present approach, that configure the present tasks as required to separately index biased attentional engagement with and disengagement from negative information (cf. Clarke, Macleod, & Guastella, 2013) could shed further light on this intriguing issue.

It will also be important for future research to extend this approach to alternative types of attentional assessment procedures. While widely used, one limitation of the attentional probe approach employed in the present study is that it provides a snapshot of attentional distribution only at the specific point when the probe appears. Hence, individual differences in attentional shifting prior to this point remain unknown. This permits the possibility that anxious participants may have shown more rapid execution of the specified

attentional goal when this involved attention towards rather than away from negative information, but that execution of both attentional goals was fully complete by the time the probe appeared. This possibility could be tested by contrasting the effects observed in the unconstrained and constrained attention conditions when using eye movement measures of attentional selectivity, which can more sensitively reveal anxiety-linked variability in the speed with which alternative attentional responses to threat are executed. It may also prove interesting for researchers to examine novel analytic procedures for assessing attentional biases when investigating anxiety-linked differences in attentional goal setting and execution. Such analytic procedures could include the assessment of the dynamic expression of attentional bias across time (e.g. Zvielli, Bernstein, & Koster, 2015).

The conclusion invited by our findings, that anxiety-linked attentional bias reflects a bias in the setting of attentional goals is consistent with observations on tasks that do not instruct participants to adopt any attentional response to negative information. For example, when steady-state visual evoked potentials have been used to measure attentional selectivity during passive viewing of emotionally valenced face pairs these measures have revealed that negative facial expressions are preferentially attended to by anxious participants (Wieser, McTeague, & Keil, 2011). Felmingham, Rennie, Manor, and Bryant (2011) assessed eye movement while participants passively viewed word sets containing an emotionally negative item and found that high anxious participants showed increased initial fixations on these negative items than did low anxious participants. Similar findings have been reported by other investigators (Lee & Lee, 2012; Nelson, Purdon, Quigley, Carriere, & Smilek, 2014). While these findings can readily be accommodated by the hypothesis that anxiety-linked attentional selectivity reflects a bias in the setting of attentional goals they do not definitively demonstrate the validity of this hypothesis. It is possible that in these studies high and low anxious participants equally likely sought to

avoid negative information but high anxious participants were selectively impaired in executing this particular attentional goal. Our own study provides direct evidence in favor of the hypothesis that the observed attentional biases reflect a bias favoring the setting of attentional goals to orient attention towards negative information.

The current study did not directly investigate the mechanisms that underpinned anxiety-linked bias in attentional goal setting. In principle, anxious individuals may either find it disproportionately difficult to set themselves the attentional goal of moving attention away from negative information, or else may find it equally easy to set the goal of attending, or avoiding, negative information, but be disproportionately inclined to set themselves the latter attentional goal rather than the former. Some insight into this issue is observed by considering how long participants paused in the Constrained Attention condition between being informed of the attentional goal and pressing the spacebar to commence the trial. If anxious participants found it disproportionately difficult to set the goal of attentionally avoiding negative information, then it might be expected that they would exhibit a disproportionate delay between receiving this particular attentional goal, and pressing the spacebar to execute it. Analysis of data reflecting the time taken between receiving a specified attentional goal in the Constrained Attention condition and pressing the spacebar to initiate the trial revealed no anxiety-linked differences in this time. Such a pattern suggests that heightened anxiety may not be characterized by disproportionate difficulty in setting the goal of attentionally avoiding negative information.

Turning now to consider methodological implications, our findings clearly suggest that anxiety-linked attentional bias to negative information is likely to be most effectively assessed by procedures that impose minimal constraints on the setting of attentional goals, and so permit maximal expression of individual differences in such goal setting. This may serve to explain some of the inconsistencies that have been observed across studies that

have sought to reveal anxiety-linked attentional bias using differing variants of visual search tasks. Typically, these studies have required participants to search through grids that contain faces showing emotional negative and non-negative expressions, and have sought to infer attentional bias by examining whether latencies are speeded under conditions in which search performance would benefit from greater attention to negative expressions. In some such studies investigators have directly instructed participants to locate an emotionally negative or non-negative face target and usually this has revealed no evidence of an anxiety-linked attentional bias for negative information (Hahn & Gronlund, 2007; Rinck, Becker, Kellermann, & Roth, 2003). Therefore, when participants have been instructed to attend towards or to attentionally avoid negative information in visual search tasks there has typically been no evidence that high and low anxious participants differ in the execution of such attentional instructions. In contrast, other studies have not instructed participants to adopt a particular pattern of attentional responding to negative information, but instead have required them to only indicate whether one facial expression differs from the rest. This instruction does not constrain participant goals with respect to selective attentional responding to negative information, and commonly such variants have found evidence of anxiety-linked attentional bias to negative information (Eastwood et al., 2005; Gilboa-Schechtman, Foa, & Amir, 1999; Hadwin et al., 2003). Therefore, anxiety-linked attentional bias to negative information is seemingly typically observed on visual-search task variants that permit maximal expression of individual differences in the setting of attentional goals to attend towards or away from negative information, rather than variants that assess individual differences in participants' execution of goals requiring of adopting each pattern of selective attentional response.

From a therapeutic perspective, our findings highlight the potential for conventional cognitive-behavioral therapies (CBT) to change anxiety-linked attentional bias. Cognitive-

behavioral therapies operate by having individuals deliberately alter biases in their information processing. The present observation that anxiety-linked elevated attention to negative information can be eliminated through the instructed manipulation of attentional goals indicates that CBT should be capable of reducing anxiety-linked attentional biases to negative information. Consistent with this, several studies have reported reductions in anxiety-linked attentional bias after completion of CBT regimes (see Tobon, Ouimet, & Dozois, 2011 for a review). For example, Mogg, Bradley, Millar, and White (1995) measured attentional bias to negative information in patients with generalized anxiety disorder (GAD) before and after the completion of a CBT schedule. While the GAD patients initially showed a heightened attention bias to negative information compared to healthy controls, after treatment these patients no longer showed such a bias. Similarly, Pishyar, Harris, and Menzies (2008) measured attentional bias to negative information in patients with social anxiety before and after the completion of a CBT schedule, and observed a reduction in attentional bias to negative information post therapy.

The change in attentional bias induced by these interventions always has been assessed using procedures that cannot distinguish between biased setting of attentional goals and biased execution of attentional goals. Adoption of the assessment approach used in the present study will be able to determine whether these intervention methods differentially alter setting and execution of attentional goals. The resulting knowledge could guide the development of interventions that most effectively alter the dimension of attentional selectivity that carries the beneficial therapeutic impact.

An additional important path for future research will be to extend this assessment approach to the investigation of attentional bias in clinical populations. While the present study indicates that high levels of trait anxiety in a non-clinical cohort are characterized by a bias to set attentional goals to attend towards relative to away from negative information

rather than a bias in the execution of these alternative attentional responses, the same may not be true for individuals suffering from clinical levels of anxiety across the continuum of anxiety vulnerability. Indeed, one could even speculate that a bias in the execution of goals to attentionally avoid negative information might prove to be a unique hallmark of anxiety pathology that differentiates anxiety disorders from non-clinical manifestations of elevated anxiety vulnerability, which instead may reflect only a bias favoring the setting of goals to attend to negative information. Because previous theoretical accounts of anxiety-linked attentional bias have failed to conceptually distinguish bias in attentional goal setting from bias in attentional goal execution this type of speculation is novel. Nevertheless it can now be easily tested by delivering the present assessment procedure to low trait anxious participants and to equally high trait anxious participants who differ in terms of whether or not these meet diagnostic criteria for clinical anxiety. Such future work will serve to determine whether indeed clinical anxiety is uniquely associated with the impaired ability execute the attentional goal of avoiding negative information, thereby shedding further light on the potentially differing cognitive mechanisms that may underpin the apparently similar attentional bias displayed by clinically anxious individuals and by high trait anxious individuals who do not exhibit clinical pathology.

The evaluation of these interesting possibilities must await the outcomes of further research. For the moment however, the present findings suggests that the attentional bias to negative information exhibited by high trait anxious individuals compared to low trait-anxious individuals reflects an attentional bias favoring the *setting* attentional goals to attend towards negative information, rather than an attentional bias impairing the *execution* of attentional goals of avoiding negative information. We hope that the novel paradigm reported in this paper, developed to differentiate these two facets of anxiety-linked attentional bias, will prove to be of continuing value in further illuminating the

specific nature of the attentional selectivity implicated in other populations including, but not limited to, people suffering from anxiety pathology

Post-print

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ATTENTION BIAS REFLECTS GOAL SETTING

Overview of trial timing

Overview of task conditions

Example trials

Figure 1. Trial timing, attentional assessment task conditions, and example trials.

ATTENTION BIAS REFLECTS GOAL SETTING

Figure 2. Attentional Bias to Negative Images Index scores in the Unconstrained Attention condition. Error bars represent standard error of the mean.

ATTENTION BIAS REFLECTS GOAL SETTING

Figure 3. Attentional Bias to Negative Images Index scores in the Constrained Attention condition. Error bars represent standard error of the mean.