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Traits, states, and attentional gates: Temperament and threat relevance as predictors of attentional bias to social threat

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This study investigated the influence of situational and dispositional factors on attentional biases toward social threat, and the impact of these attentional biases on distress in a sample of adolescents. The results suggest greater biases for personally relevant threat cues, as individuals reporting high social stress were vigilant to subliminal social threat cues, but not physical threat cues, and those reporting low social stress showed no attentional biases. Individual differences in fearful temperament and attentional control interacted to influence attentional biases, with fearful temperament predicting biases to supraliminal social threat only for individuals with poor attentional control. Multivariate analyses exploring relations between attentional biases for social threat and symptoms of anxiety and depression revealed that attentional biases alone were rarely related to symptoms. However, biases did interact with social stress, fearful temperament, and attentional control to predict distress. The results are discussed in terms of automatic and effortful cognitive mechanisms underlying threat cue processing.

Keywords: attentional bias; temperament; social stress; subliminal; supraliminal; dot probe

Temperament and threat relevance as predictors of attentional bias to social threat

Attentional allocation involves a rich network of automatic and volitional processes, which may be influenced by both situational factors and individual differences (Gilboa-Schechtman, Revelle, & Gotlib, 2000; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Matthews & Wells, 2000; Rueda, Posner, & Rothbart, 2004). Hundreds of studies have investigated relations between state or trait anxiety and attentional biases, demonstrating a consistent link between anxiety and vigilance to threat. Temperament traits involving sensitivity to threat (e.g., negative affectivity, trait anxiety) are associated with automatic allocation of attention to threat (Derryberry & Reed, 2002; Mansell, Ehlers, Clark, & Chen, 2002), and are strongly linked to symptoms of anxiety and depression (Compas, Connor-Smith, & Jaser, 2004; Muris, de Jong, & Engelen, 2004; Rothbart, Posner, & Hershey, 1995), bolstering the notion that threat cue vigilance is problematic. Although vigilance to threat is often discussed as a potential *cause* of anxiety, attentional biases may also be a *response* to anxiety or stress, as individuals are more likely to be vigilant to threat cues relevant to current concerns. For example, women with cancer are

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vigilant to supraliminal cancer threat words (Glinder, Beckjord, Kaiser, & Compas, 2007), and children with chronic abdominal pain are vigilant to subliminal pain threat words (Boyer et al., 2006), while neither group is vigilant to social threat words. Despite links between attentional biases and distress, emerging evidence suggests that vigilance to threat may be associated with positive outcomes under some circumstances (Boyer et al., 2006, Glinder et al., 2007; Luecken, Tartaro, & Appelhans, 2004). Unfortunately, because few studies have explored the interplay of situational factors, such as stress level, and dispositional factors, such as temperamental vulnerability to stress and capacity to regulate attention, little is known about how these factors interact to influence attentional biases or their consequences.

The dot probe task is a common measure of attentional allocation in which a series of paired stimuli (one threatening and one neutral) is presented to participants, followed by a target probe that replaces either the threatening or neutral stimulus. Vigilance toward threat is evidenced by faster responses to probes replacing threat cues, avoidance by slower responses (Mathews & MacLeod, 1994). A recent meta-analysis of dot probe studies indicated that non-anxious individuals avoid subliminal threat, and show no attentional bias for supraliminal threat, whereas state and trait anxious individuals are vigilant to both subliminal and supraliminal threat (Bar-Haim et al., 2007). Because the majority of past work has asked whether anxious individuals show greater bias to threat than to neutral words, or whether anxious and non-anxious individuals differ in their allocation of attention to threat, a great deal of evidence documents the co-occurrence of attentional biases and anxiety. However, much less is known about how individual differences in vulnerability specifically interact with attentional bias to predict distress.

Impact of attentional biases

Vigilance to subliminal threat has been linked to anxiety disorders (Luecken et al., 2004; Mathews & MacLeod, 1994; Yovel & Mineka, 2005), discomfort in children with chronic abdominal pain (Boyer et al., 2006), somatic complaints (Lundh, Wilkstrom, & Westerlund, 2001), trait anger (Van Honk, Tuiten, de Haan, van den Hout, & Stam, 2001), panic symptoms (Nay, Thorpe, & Roberson-Nay, 2004), and increased distress following negative life events (MacLeod & Hagan, 1992). Supraliminal threat bias, too, has been linked to an array of psychological symptoms (see McCabe & Gotlib, 1995; Pishyar, Harris, & Menzies, 2004; Vasey, El-Hag, & Daleiden, 1996) even though in anxious samples the magnitude of supraliminal bias is about half that of the subliminal threat bias (Bar-Haim et al., 2007). Notably, however, several studies assessing both stress and distress suggest that vigilance to supraliminal threat may have benefits. For example, supraliminal vigilance to personally relevant threat cues predicts less emotional distress and greater positive affect in cancer patients (Glinder et al., 2007), lower parent-reported pain in children with chronic abdominal pain (Boyer et al., 2006), and more strategic coping in a community sample (Luecken et al., 2004). Thus, although distressed samples often show bias toward supraliminal threat, this bias may not be inherently problematic. Intentionally allocating attention toward relevant threat cues may facilitate information processing, assist in accurate assessment of threat, or facilitate strategic coping.

Bar-Haim and colleagues (2007) recently proposed a model describing the dynamics of pre-conscious and conscious attentional processes and their impact on anxiety. In this model, an automatic, pre-attentive process continuously scans the environment to evaluate the threat level of stimuli. In dot probe studies, responses to subliminally presented cues are used to assess this automatic process. Stimuli tagged by this automatic, pre-attentive process as representing potential threat may trigger emotional arousal, physiological arousal, and conscious orientation toward the threat cues. These consciously perceived stimuli are further evaluated in terms of past experiences and the current context to determine the nature and intensity of threat. The model predicts that confirmation of threat will be associated with continued arousal and orientation to threat cues, disconfirmation with decreased arousal, lowered anxiety, and attentional shifting away from the negative stimuli. In dot probe studies, responses to supraliminally presented cues reflect the operation of volitional and conscious processes, as well as the impact of automatic processes on attention.

Anxiety may be produced by either pre-conscious or conscious processing biases, such as excessive automatic vigilance, an inappropriately low threshold for triggering conscious processing, unwarranted conscious processing of low threat stimuli, miscategorization of benign stimuli as threatening, or an inability to inhibit automatic threat alerts after consciously determining that threat is minimal (Bar-Haim et al., 2007). Thus, vigilance to supraliminal threat cues may be problematic if it reflects involuntary attentional capture and inability to disengage from threat cues, but beneficial if attention to threat is in the service of accurately assessing the nature and degree of risk. The results of studies linking supraliminal threat cue vigilance to symptoms may be mixed because the meaning of vigilance may be influenced by the capacity of an individual to voluntarily regulate attention to threat cues (Derryberry & Reed, 2002).

Attentional control

The temperament trait of attentional control reflects stable individual differences in the ability to monitor attentional allocation and to effortfully maintain or disengage attention (Rothbart, Ellis, & Posner, 2004; Rueda et al., 2004). Attentional control is associated with low levels of anxiety and depression (Compas et al., 2004; Muris et al., 2004; Rothbart et al., 1995), and has been shown to moderate relations between vulnerable temperament and distress. Studies exploring interactions of attentional control and negative affectivity suggest that the combination of high negative affectivity and low attentional control most strongly predicts distress (Lonigan & Phillips, 2001; Muris, 2006).

Thus far, very few studies have explored the role attentional control plays in attentional biases and subsequent threat processing. It seems likely that the optimal degree of vigilance to threat is likely to depend both on the extent to which threat cues are relevant to current stressors, and on the degree of temperamental vulnerability to threat. For example, vigilance in an individual high in fearful temperament and low in attentional control may indicate uncontrolled attentional capture, whereas vigilance for an individual low in fearful temperament and high in attentional control may reflect intentional processing of cues relevant to the current context. As a result, individuals low in fearful temperament may be able to effectively

process threat cues immediately, whereas individuals high in fearfulness may need to limit intake of threat cues in order to manage physiological and emotional arousal. Similarly, individuals high in attentional control should be able to consciously attend to or disengage from threat cues as appropriate to the situation (Derryberry & Reed, 2002), potentially mitigating risks associated with automatic vigilance to threat.

Overview of the present study

This study explored how situational and dispositional factors interact to influence attentional allocation and the impact of attentional allocation on distress. A community sample of children making the transition into middle school was selected to ensure a range of scores for fearful temperament and attentional control. Attentional biases for social threat cues were assessed, as negative peer interactions are both common and significant in this age group. Because attentional biases in community samples are rare, we did not expect attentional biases in the full sample at either the subliminal or supraliminal level. Instead, we anticipated that threat cue relevance and fearful temperament would predict greater vigilance to threat. To test the impact of threat cue relevance, participants were exposed to two types of threat cues: physical threat and social threat. Bias for social threat cues, but not physical threat cues, was expected to be more pronounced for participants reporting high social stress than for those reporting low levels of stress. This pattern of attentional bias was expected to be clearest for subliminal cues reflecting purely automatic processing, as responses to supraliminal cues should also reflect individual differences in volitional regulation of attention. Strong attentional control capacity was expected to buffer the impact of fearful temperament on attentional biases to supraliminal social threat. Finally, building on the few studies investigating relations between attentional biases and outcomes (Boyer et al., 2006; Glinder et al., 2007; MacLeod & Hagan, 1992; MacLeod et al., 2002), this study explored how attention to social threat, social stress, fearful temperament, and attentional control interact to predict symptoms of anxiety and depression.

Method

Participants

The initial sample consisted of 125 sixth graders recruited from local middle schools. Four participants were excluded because they had minor difficulties reading dot probe directions out loud, suggesting potential reading problems that might decrease task validity. The remaining 121 students (59 girls and 62 boys) ranged in age from 10 to 13 years with a mean age of 11.36 years. Eighty-six percent of participants identified themselves as White, 7.3% as Native American, 4.1% as Asian or Pacific Islander, 1.6% as Hispanic, and 1% as Black.

Procedure

The present study was part of a larger, two-phase project assessing social stress and coping in middle school students. Separate parental consent and child assent was obtained for each phase of the study. Adolescent self-report questionnaires were

completed during Phase I, which occurred at students' schools during a study hall period. Students were compensated with a \$5 gift certificate. Students completing Phase I were eligible to participate in Phase II, a 90-minute laboratory session, during which the dot probe task was administered. Seventy-six percent of Phase I participants elected to participate in Phase II. Youth participating in Phase II received \$20 in gift certificates. The two phases happened within six weeks of each other, with an average of 42 days between Phase I and Phase II.

Measures

Dot probe task

The dot probe task in this study was administered using E-Prime computer software (Psychology Software Tools, 2001). All participants completed the task individually in the same room under identical lighting conditions, seated 60 centimeters from the computer screen. Before each trial, a white fixation marker ("+") presented for one second readied participants for the introduction of the word pair stimulus. Word pairs were centered, with 3 centimeters between the top and bottom word. In each trial, one word was replaced with a white dot. Participants were instructed to respond to the dot probe stimulus as quickly as possible by pushing one of two keyboard buttons ("upper" or "lower") to indicate which word had been replaced by the dot probe. Response accuracy and response time in milliseconds (ms) were recorded by the computer for each trial.

Each word pair stimulus consisted of a neutral word (household objects such as patio or plate) paired with one of 20 social threat words (e.g., coward, moron) or one of 20 physical threat words (e.g., suffer, bleed). Neutral and threat words were of equivalent length and frequency of usage, and at a fourth to sixth grade reading level (see Boyer et al., 2006 for a detailed description of word selection and task design). Each word pair was presented once at the subliminal level and once at the supraliminal level. In addition, 20 word pairs containing only neutral words were presented at both the subliminal and supraliminal level so participants would not expect a threat word on each trial. In the subliminal condition, word pairs were presented for 20 ms and then masked by an equal-length meaningless string of consonants for 1230 ms before the dot probe appeared. In the supraliminal condition, participants viewed the word pair stimulus for 1250 ms, followed by the dot probe replacement. The 120 within-subjects trials were presented in a different random order for each participant. Attentional bias toward threat is indicated by faster responses to dot probes replacing threat words; avoidance of threat by faster responses to probes replacing neutral words.

Lexical decision task

A lexical decision task was used to verify that participants were not consciously aware of words presented in the subliminal condition. In each trial, the computer flashed two words on the screen for 20 ms before covering these words with a meaningless string of consonants. In half of the trials, the masked words were real, in the other half they were not (see Boyer et al., 2006). Participants were asked to indicate whether or not real words had been presented before being masked by the

random string of consonants. An accuracy rating of 50% for identification of real versus non-real words would indicate that individuals were not able to consciously process words shown for 20 ms.

Social stress

Students reported social stress using the 50-item Stressful Situations Questionnaire (SSQ), which asks participants to report whether stressful events from academic, social, family, and public domains have occurred in the last six months, and to rate the impact of events that took place on a scale from 0 (*Not bad at all*) to 4 (*Extremely bad*). The SSQ is an abbreviated version of the Adolescent Perceived Events Scale (APES), which has excellent internal consistency, test-retest reliability, and concurrent validity (Compas, Davis, Forsythe, & Wagner, 1987), supplemented with social stress items from other reliable and valid measures of child stress. From this questionnaire, a total social stress score based on the 17 social stress items was calculated by summing the impact ratings of social stressors experienced. Social stressors included teasing, peer pressure, fights with friends, and rejection. For categorical analyses, low social stress was defined as scores ½ *SD* below the mean ($N = 39$), high social stress as scores ½ *SD* above the mean ($N = 42$), and medium social stress as scores from ½ *SD* below to ½ *SD* above the mean ($N = 31$).

Temperament

For each participant, temperament data were gathered using the self-report Early Adolescent Temperament Questionnaire-Revised (EATQ-R; Ellis & Rothbart, 2001), which assesses temperament, self-regulation, and behavioral problems. Fearful Temperament was assessed using the EATQ-R fear subscale ($\alpha = .66$), which reflects a tendency toward unpleasant anticipation of distress. Attentional Control was assessed by averaging Z scores from the inhibitory control subscale, which measures capacity for effortful suppression of inappropriate responses as well as the ability to plan, and the attention subscale, which measures capacity for volitional focus and shifting of attention. This composite was chosen to capture the voluntary regulation of attention and the ability to inhibit automatic responses. Internal consistency of this composite measure was strong ($\alpha = .78$).

Depression

The Depressive Mood subscale of the child-report EATQ-R was used to assess sad affect and loss of interest in activities. The internal consistency for the measure was satisfactory ($\alpha = .61$).

Anxiety

Participants completed the 112-item Youth Self Report (YSR; Achenbach & Rescorla, 2001) which assesses emotional and behavioral problems. The six-item Anxiety scale ($\alpha = .68$), based on the DSM-oriented scoring criteria, was used to measure symptoms of anxiety, fear, and worry.

Results

First, attentional bias scores were calculated from the dot probe data, and the lexical decision task was analyzed to ensure that subliminal cues were truly outside conscious awareness. Second, the impact of threat cue relevance on attentional biases was explored using a three-way mixed design analysis of variance (ANOVA), with threat type and exposure duration as within subject factors and stress level as a between subjects factor. Third, the capacity of attentional control to moderate the impact of fearful temperament on attentional bias was tested using regression analyses. Finally, ways in which attention to social threat, social stress, fearful temperament, and attentional control interact to predict symptoms of depression and anxiety were tested using regressions.

Dot probe data preparation

Before analysis, raw data were evaluated for inaccurate and outlying responses. For all participants, response latencies for incorrect responses about probe location were dropped (less than 3.5% of the data), and reaction times less than 200 ms or greater than 2000 ms (less than .5% of the data) were removed as error. Once attentional bias scores were calculated, nine participants with one or more bias scores falling 2.5 *SD*s above or below the group mean bias score for each condition were removed, following procedures used by Boyer and colleagues (2006). Inspection of scores for these nine participants suggested that they were similar to the remaining sample for Fearful Temperament, Attentional Control, Depression, and Anxiety, but were lower in Social Stress ($M = 9.0$ versus 14.9).

For each participant, attentional bias scores representing the average response time difference for targets occurring in neutral versus threat locations were calculated for subliminal physical threat, subliminal social threat, supraliminal physical threat, and supraliminal social threat conditions. Bias scores were based on the standard equation, $\frac{1}{2}[(UpLt - UpUt) + (LpUt - LpLt)]$ (MacLeod & Mathews, 1988), with $U =$ upper position, $L =$ lower position, $p =$ probe, and $t =$ threat. Thus, $UpLt$ indicates the mean response latency for trials in which the threat word is in the lower position and the probe replaces the neutral word in the upper position. A positive score indicates bias toward threat; a negative score indicates bias away from threat; a score of zero indicates the absence of bias.

Mean bias scores were 4.48 ($SD = 69.38$) for subliminal physical cues, 3.40 ($SD = 69.88$) for subliminal social cues, 2.03 ($SD = 68.23$) for supraliminal physical cues, and 3.60 ($SD = 64.07$) for supraliminal social cues. None of these scores was significantly different from zero, indicating no attentional bias in the full sample.

Lexical decision task

Accuracy scores on the lexical task were analyzed to ensure that participants were not able to discriminate between real and nonsense words presented subliminally. The percent of trials in which students correctly identified words or non-words was calculated for each participant. Mean response accuracy was 47% ($SD = 8\%$), and no individual performed reliably better than chance, indicating that individuals could not distinguish between real and nonsense words presented subliminally. This makes

it reasonable to consider responses to subliminal threat cues in the dot probe task a reflection of cognitive processes taking place without conscious awareness.

Threat cue relevance

A Threat Type (social, physical) × Stress (low, medium, high) × Exposure Duration (subliminal, supraliminal) mixed design ANOVA was conducted to look at threat related biases at differing levels of social stress. Attentional biases for social threat cues were expected to be more pronounced in individuals facing high levels of social stress than in individuals facing low levels of social stress, and these biases were expected to be specific to social threat cues. Because it was expected that personal relevance of threat cues would affect automatic stages of attentional orienting (e.g., Bar-Haim et al., 2007; Boyer et al., 2006), this pattern of attentional bias was expected to be most evident in subliminal threat cue presentations. Thus, the predicted effects would be demonstrated either in a two-way interaction of threat type and stress, or in a three-way interaction of threat type, stress, and exposure duration. Main effects for threat type, stress level, and exposure duration were all non-significant, indicating that the magnitude of threat-related attentional biases did not differ for social and physical threat cues, high and low social stress groups, or subliminal and supraliminal exposures in the full sample. The Threat Type × Exposure Duration and Threat Type × Stress level interactions were also non-significant. However, the three-way interaction of threat type, stress level, and exposure duration was significant, $F(2, 109) = 3.39$, $p < .05$.

The specific nature of the interaction was explored using Social Stress × Exposure Duration ANOVAs for physical and social threat words separately. The medium stress group was omitted, as the primary interest was in the difference between high and low stress groups. As can be seen in Figure 1, the pattern of results suggest that the three-way interaction was driven by social threat words, with the simple interaction of social stress and exposure duration approaching significance for social threat words, $F(1, 79) = 2.31$, $p = .12$, but not physical threat words. Individuals high in social stress tended to be vigilant to subliminal social threat ($M = 18.12$, $SD = 68.06$), but not supraliminal threat ($M = -4.84$, $SD =$
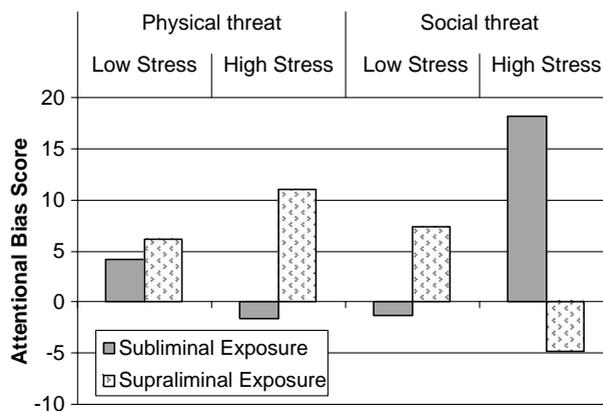

Figure 1. Attentional bias for low and high social stress groups.

68.98), while individuals low in social stress showed no attentional biases toward social threat at either the subliminal ($M = -1.25$, $SD = .13$) or supraliminal ($M = 7.31$, $SD = 60.68$) levels.

Attentional control as a moderator of relations between fearful temperament and attentional bias

Regression analyses were used to test the hypothesis that attentional control would moderate relations between fearful temperament and attention to social threat. To take advantage of the continuous nature of the temperament measures, moderation was tested by constructing a regression equation that included fearful temperament, attentional control, and a multiplicative term representing the interaction of the two traits (Aiken & West, 1991). All predictors were centered to maximize interpretability and minimize potential problems with multicollinearity. Because social stress was related to attentional biases, all regressions also controlled for total social stress. Separate regressions were performed for sub- and supraliminal social threat cues. Fearful temperament was expected to predict stronger attentional biases. Attentional control was not expected to show any relationship to subliminal social bias, which reflects purely automatic attentional allocation, but was expected to interact with fearful temperament to predict supraliminal social bias. The subliminal social model explained 3% of the variance in bias to subliminal social threat cues, $F(4, 107) = .87$, $p = .48$. Neither temperament trait, nor the interaction of fearful temperament with attentional control was a significant predictor.

The supraliminal social model accounted for 10% of the variance in supraliminal social bias, $F(4, 107) = 3.01$, $p < .05$. Once again, neither fearful temperament nor attentional control was a significant predictor. However, as expected, attentional control did interact with fearful temperament to predict attention to supraliminal social threat cues, $t = 2.90$, $p < .01$. Figure 2 shows the simple slopes for the relation between fearful temperament and supraliminal social bias plotted at high ($+1$ SD) and low (-1 SD) levels of attentional control. The slope at high levels of attentional control was not significantly different from zero, indicating that there is no relationship between fearful temperament and allocation of attention to supraliminal social threat for individuals with a strong ability to regulate attention. However,
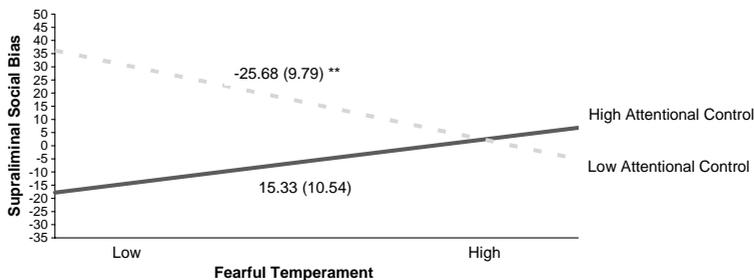

Figure 2. Interaction of fearful temperament and attentional control in predicting supraliminal social bias. Simple slopes are presented for values one SD above and below the mean for Attentional Control. Values depicted are unstandardized regression coefficients; standard errors are in parentheses. **$p < .01$.

for individuals low in attentional control, only those who were also low in fearful temperament attended to supraliminal social threat cues. Higher levels of fearful temperament were linked to greater avoidance of supraliminal social threat cues.

Relations between attentional bias and distress

Despite a well-established relationship between threat cue vigilance and psychological distress, it is not clear whether attentional biases are harmful to all people across all circumstances. A more nuanced understanding of the interplay between social context and dispositional traits, along with consideration of differences between automatic and controlled attention, is essential. Regression analyses were used to test relations between social threat biases and symptoms of distress, and to explore ways in which these relationships might be moderated by social stress, fearful temperament, and attentional control. One set of two regressions was run predicting anxiety from either subliminal or supraliminal social threat bias scores plus all possible two-, three-, and four-way interactions of bias, social stress, fearful temperament, and attentional control (see Table 1). Another set of two regressions was run predicting depression from these same variables. For simplicity, because this paper focuses on attentional bias, interactions not involving bias scores will not be discussed. As above, interactions with bias scores were explored using simple slope analyses for high ($+1$ *SD*) and low (-1 *SD*) levels of each variable.

Main effects of predictors

In both the sub- and supraliminal models, bias scores alone were typically not direct predictors of distress. The one exception to this was the weak, but significant, association between bias for subliminal social threat and depression. As expected, fearful temperament predicted greater anxiety and depression in all analyses. Social stress was correlated positively with anxiety and depression, but this relationship was only significant in the supraliminal models. Attentional control was significantly and negatively associated with symptoms of depression.

Relations between social threat bias and anxiety

The subliminal social threat model accounted for 45% of the variance in self-reported anxiety. There were significant interactions between social stress and attentional control, and between social stress, fearful temperament, and attentional control, which will not be discussed. Most notable to the present hypotheses was the three-way interaction involving fearful temperament, attentional control, and subliminal social bias, $t = 2.76$, $p < .01$. As shown in Figure 3, individuals low in fearful temperament exhibited fewer symptoms of anxiety than those high in fearful temperament. For individuals low in fearful temperament, bias to subliminal social threat cues predicted anxiety only for those low in attentional control. In contrast, for individuals with low fearful temperament and high attentional control, subliminal attentional biases were unrelated to anxiety, suggesting that a high degree of attentional control is able to buffer the negative impact of subliminal vigilance for individuals with a low temperamental vulnerability to threat. For individuals high in fearful temperament and low in

Table 1. Interactions of attentional bias, fearful temperament, attentional control, and social stress in predicting anxiety and depression.

| | Prediction of anxiety symptoms | | | | Prediction of depression symptoms | | | |
| | Subliminal social | | Supraliminal social | | Subliminal social | | Supraliminal social | |
Step	R^2	β at final step	R^2	β at final step	R^2	β at final step	R^2	β at final step
1. Social stress	.30	.17	.30	.30**	.40	.15	40	.21*
Bias		.17		−.01		.18*		.04
Fear		.34***		.24**		.44***		.41***
Attn		−.10		−.14		−.28**		−.25*
2. StressxBias	.32	.15	.34	.18	.46	.29**	.41	.08
Fear × Bias		−.02		−.18*		−.05		.07
Attn × Bias		.10		.12		.22*		.01
3. Stress × Fear × Bias	.34	−.01	.36	.20	.48	.12	.43	.20
Stress × Attn × Bias		−.11		−.23		.05		−.17
Fear × Attn × Bias		.34**		.01		.21		.03
4. Stress × Fear	.45	.16	.43	.28	.49	.01	.45	.16
Stress × Attn		.26*		.04		.09		.09
Fear × Attn		−.19		−.10		−.02		−.06
Stress × Fear × Attn		−.39**		−.23		−.04		−.08
5. Stress × Fear × Attn × Bias	.45	.07	.43	−.09	.50	−.17	.46	.10
	$F(15, 96) = 5.29***$		$F(15, 96) = 4.91***$		$F(15, 96) = 6.48***$		$F(15, 96) = 5.40***$	

Beta weights are from the final step of the regression equations and represent the unique contribution of each variable.
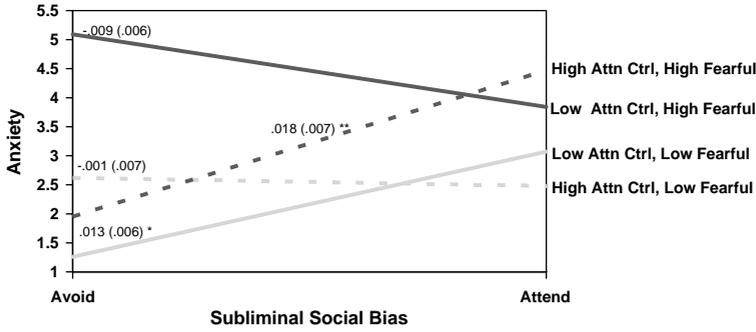*$p < .05$, **$p < .01$, ***$p < .001$.

Figure 3. Interaction of fearful temperament, attentional control, and subliminal social bias in predicting anxiety. Simple slopes are presented for values one *SD* above and below the mean of fearful temperament and attentional control. Values depicted are unstandardized regression coefficients; standard errors are in parentheses. *$p < .05$, **$p < .01$.

attentional control, patterns of attention to subliminal social cues were unrelated to anxiety, as these individuals showed high levels of anxiety regardless of avoidance or attention to subliminal threat cues. However, attentional patterns did matter for high fearful temperament individuals who were also high in attentional control. Although avoidance of subliminal social threat had no benefits for high fearful temperament/low attentional control individuals, for high fearful temperament/high attentional control individuals, avoidance was associated with low anxiety, with symptom levels comparable to those of low fearful temperament individuals. High attentional control, therefore, was not sufficient to protect individuals with fearful temperament from the negative impact of vigilance to subliminal social cues.

The supraliminal social model accounted for 43% of the variance in self-reported anxiety. Although bias alone was completely unrelated to anxiety symptoms ($\beta = -.01$), fearful temperament interacted with supraliminal social bias to predict anxiety, $t = -1.93$, $p = .05$ (see Figure 4). Level of fearful temperament appeared irrelevant for individuals attending to supraliminal social threat cues. However, avoidance of supraliminal social threat cues was associated with anxiety for individuals high in fearful temperament, but not for those low in fearful temperament.
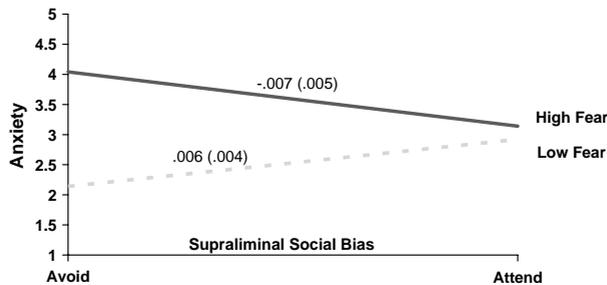

Figure 4. Interaction of fearful temperament and supraliminal social bias in predicting anxiety. Simple slopes are presented for values one *SD* above and below the mean of fearful temperament. Values depicted are unstandardized regression coefficients; standard errors are in parentheses.

Relations between social threat bias and depression

The subliminal social threat model accounted for 50% of the variance in depressive symptoms. Subliminal social bias interacted with social stress, $t = 3.02$, $p < .01$, and attentional control, $t = 2.35$, $p < .05$, to predict depression (see Figure 5). Analysis of simple slopes for the interaction of stress level with subliminal social bias indicated that attentional patterns were unrelated to depressive symptoms for those with low stress. However, for those facing high levels of social stress, vigilance to subliminal social threat predicted greater depression. Importantly, regressions demonstrated that when high stress was paired with avoidance of subliminal social threat cues, resulting symptom levels were comparable to those of individuals with low social stress. Analysis of the interaction of subliminal social bias and attentional control indicated that attentional allocation to subliminal threat was irrelevant for individuals low in attentional control, whose symptoms remained steady across attentional patterns. However, for individuals high in attentional control, subliminal threat cue avoidance was associated with lower levels of depressive symptoms.

The supraliminal social threat model accounted for 46% of the variance in depressive symptoms. Although none of the interactions with supraliminal bias was significant, the three-way interaction of social stress, fearful temperament, and supraliminal bias approached significance, $p = .08$, suggesting a possible direction for future research.

Discussion

Because links between attentional biases and anxiety are well established, the primary goal of this study was to understand how attentional patterns and their
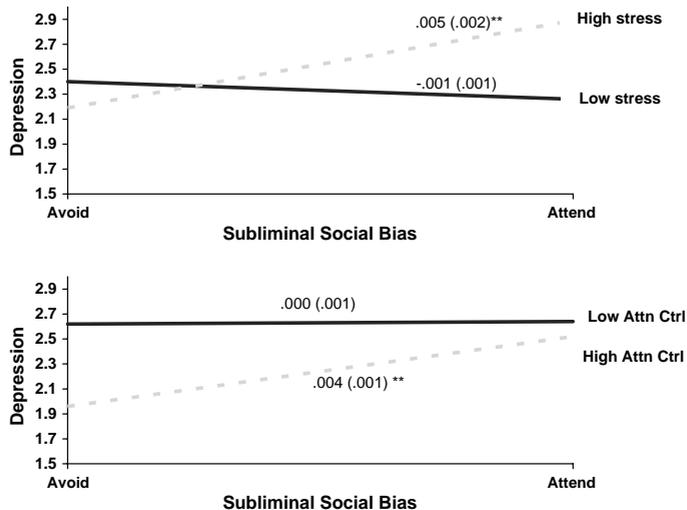

Figure 5. Interaction of subliminal social attentional bias and social stress, and subliminal social bias and attentional control in predicting depression. Simple slopes are presented for values one *SD* above and below means for social stress. Values depicted are unstandardized regression coefficients; standard errors are in parentheses. **$p < .01$.

impacts are influenced by threat cue relevance and dispositional factors. The results indicate that attentional biases are shaped both by external factors, such as stress level, and by internal factors, such as fearful temperament and attentional control. The results also suggest that attention to situational and dispositional factors will enrich our understanding of relations between attentional biases and distress.

Threat cue relevance

As expected, attentional biases were not seen in the full sample or in individuals with low stress levels. However, as in past studies (e.g., Gilboa-Schechtman et al., 2000), threat cue relevance shaped early stage attention to threat. Individuals reporting higher social stress over the last six months tended toward vigilance to subliminal social threat cues, but not subliminal physical threat cues. The fact that threat cue relevance was important for subliminal, but not supraliminal, cues highlights the importance of distinguishing between automatic and volitional aspects of threat processing.

The multi-stage model of threat processing proposed by Bar-Haim and colleagues (2007) suggests the involvement of four cognitive systems in processing threatening stimuli. Subliminal attentional orientation to environmental cues is governed by the Preattentive Threat Evaluation System (PTES), which automatically scans the environment for signs of threat, passing stimuli representing potential threat to the Resource Allocation System (RAS). The RAS prompts physiological and emotional arousal, engages cognitive resources for threat cue processing, and interrupts activity not related to threat cue processing. Next, the Guided Threat Evaluation System (GTES) assesses the perceived threat in terms of past experiences, current context, and the resources available. If the GTES determines threat is present, emotional and physiological arousal will persist, and the Goal Engagement System (GES) will allocate resources to continued response. If the stimulus is judged as benign, the GTES will override alert signals from the RAS and PTES, arousal will diminish, mildly negative stimuli will be ignored, and other activities will be resumed.

Responses to subliminal threat cues on the dot probe task reflect only the automatic activity of the PTES. By comparison, responses to supraliminal cues reflect the array of post-attentive processes described in the Bar-Haim model, as well as the continuing impact of automatic threat scanning. Because each processing stage presents opportunities for individual differences in conscious evaluation of threat and attentional regulation capacity, it is not surprising that the impact of stress on attention is strongest at the subliminal level. Although it seems logical to assume that stressful life contexts influence threat scanning and assessment, it is also likely that vigilance to threat enhances perceptions of stress. Vigilance to subliminal social threat cues may lead individuals to perceive social interactions as more stressful. Laboratory studies using standardized stressors can help to disentangle relations between attentional biases and perceived stress.

Temperament and attentional bias

Temperament may be related to both automatic and conscious aspects of attentional allocation. Traits associated with sensitivity to threat, such as fearful temperament, are linked to a negative scanning bias, greater emotional and physiological reactivity

to threat, a lower threshold for identifying stimuli as negative, and a more ruminative processing style (Bolger & Schilling, 1991; Reed & Derryberry, 1995; Roberts, Gilboa, & Gotlib, 1998; Robinson, Vargas, Tamir, & Solberg, 2004). Although individuals high in fearful temperament are likely to have more difficulty disengaging from supraliminal threat cues than are individuals low in fearful temperament, they may also have greater motivation to do so in order to minimize unpleasant emotional and physiological arousal. Particularly for individuals high in fearful temperament but low in attentional control, disengagement with threat may be the most plausible route for self-regulation. Fearful individuals who are also high in attentional control, however, should have a greater capacity to override automatic threat cue alerts and ignore negative stimuli deemed to represent low threat.

In this study, fearful temperament did not show the expected direct relationship to greater subliminal and supraliminal threat vigilance. Because many studies linking threat-vulnerable temperament to attentional biases focused on individuals with high trait vulnerability (Bar-Haim et al., 2007) it may be that this community sample did not have sufficient range to assess relations between fearful temperament and attentional bias. At the supraliminal level, however, the relationship between fearful temperament and consciously perceived threat was moderated by attentional control. For individuals high in attentional control, fearful temperament was unrelated to supraliminal social threat cue bias. Among individuals with poor attentional control, those low in fearful temperament attended to supraliminal threat cues, with increases in fearful temperament predicting increased orientation away from threat. Because low attentional control is linked to poor self-regulation (Derryberry & Reed, 2002; Muris, 2006; Rothbart et al., 2004; Rueda et al., 2004), this avoidance of threat may be indicative of a need to resort to disengagement as a means of self-regulation, rather than engaging productively with threatening stimuli to evaluate the nature and degree of threat.

Relations between attentional bias, stress, temperament, and distress

Attentional biases alone were typically not directly associated with symptoms of distress, with only subliminal social vigilance predicting increased depression. Instead, the impact of attentional allocation depended on an individual's context, their degree of temperamental vulnerability, and their capacity to effortly regulate attentional focus.

Only one model demonstrated a relationship between supraliminal bias and distress: fearful temperament and supraliminal social bias interacted to predict risk for anxiety. Overall, although individuals high in fearful temperament reported greater anxiety, differences in anxiety symptoms were most clear for individuals who avoided supraliminal social threat cues. Avoidance of supraliminal threat cues was linked to fewer symptoms for individuals low in fearful temperament, but more symptoms for those high in fearful temperament. The observed pattern of results suggests that while avoidance of threat cues may have short term benefits for easily distressed individuals, the failure to fully process threat cues may have negative long-term consequences. For example, previous studies have suggested that socially anxious individuals facing a social threat tend to avoid pictures of both positive and negative facial expressions (Chen, Ehlers, Clark, & Mansell, 2002; Mansell, Clark, Ehlers, & Chen, 1999). This tendency to avoid processing social cues may have the

short term benefit of reducing exposure to distressing information, but it may also make it difficult for socially anxious individuals to accurately read the reactions of others, interfering with their ability to recognize social successes or to adapt their behavior in response to others.

Interestingly, although high attentional control was associated with less risk for distress, attentional control did not moderate relations between supraliminal bias and symptoms. Instead, the psychological benefits of attentional control appeared to be dependent upon patterns of subliminal attention. Strong attentional control was associated with fewer distress symptoms typically when accompanied by subliminal avoidance of threat. It is an interesting question for future research whether attentional control may also serve to buffer the downstream consequences of moderate levels of subliminal bias for threat by managing post-attentive processing of automatic threat alerts, overriding automatic threat alerts when appropriate, regulating emotional and physiological arousal, or supporting effective coping.

Perhaps the best illustration of the complex interplay between attentional bias, temperament, and distress is seen in Figure 3, which diagrams the interaction of fearful temperament, attentional control, and subliminal social bias as predictors of anxiety symptoms. For individuals low in fearful temperament and high in attentional control, attentional allocation to subliminal threat cues was irrelevant. These temperamentally shielded individuals showed low risk for anxiety symptoms whether they avoided or attended to subliminal threat cues. Similarly, attentional allocation was irrelevant for individuals high in fearful temperament and low in attentional control, as these doubly vulnerable individuals showed high levels of anxiety regardless of their allocation of attention to subliminal threat. However, for individuals with mixed levels of temperamental vulnerability, attentional biases were relevant to anxiety symptoms. For both low fearful temperament/low attentional control individuals and high fearful temperament/high attentional control individuals, subliminal threat cue vigilance predicted greater anxiety. The impact of attentional control was seen most clearly for high fearful temperament individuals. Those with poor capacity to effortfully regulate attention showed no benefits of subliminal threat cue avoidance, whereas those with strong self-regulation capacity showed clear benefits of subliminal threat cue avoidance, with symptom levels comparable to those of low fearful temperament individuals. Similarly, in the model predicting depression from subliminal attentional patterns (Figure 5), attentional allocation was not related to depressive symptoms for individuals low in attentional control, but avoidance of subliminal threat cues showed benefits for individuals high in attentional control. Overall, results suggest that the link between attentional control and distress is, in part, moderated by early-stage attentional allocation as well as by the presence or absence of other temperamental vulnerabilities.

Psychological outcomes associated with vigilance to subliminal social threat were also related to stress level. For individuals under low stress conditions, attention to subliminal social threat cues was unrelated to depression; however, under high stress conditions, vigilance to subliminal social threat cues predicted depressive symptoms. These findings support other work showing that attentional biases may be most harmful for individuals experiencing ongoing life stress. For example, the tendency to increase vigilance to threat cues in response to negative mood induction in the laboratory predicted an increase in dysphoria over a 6–8 week period for participants who experienced high life stress, but was unrelated to symptoms for those

experiencing low stress (Beevers & Carver, 2003). The automatic tendency to scan the environment for threat may be most harmful if the individual's social context makes it likely that threat will be repeatedly discovered. Although subliminal vigilance is more commonly linked to anxiety than depression, frequent alerts about potential threat may trigger elaborative processing that ultimately increases risk for depression.

Limitations and future directions

The present research adds to the small number of dot probe studies assessing both subliminal and supraliminal attentional biases (Boyer et al., 2006; Glinder et al., 2007; Luecken et al., 2004) and the potential risks and benefits of attention at each level. Although past research has suggested that subliminal bias toward threat cues is linked to poor outcomes (Boyer et al., 2006; Luecken et al., 2004; Lundh et al., 2001; MacLeod & Hagan, 1992; Mathews & MacLeod, 1994; Nay et al., 2004; Van Honk et al., 2001; Yovel & Mineka, 2005), it is not yet clear whether this link is due to the direct relationship between attentional bias and outcomes or to the underlying trait- and environment-based vulnerabilities that guide both attentional processes and outcomes. This study began to tease apart this relationship by examining the impact of temperament and stress on attentional patterns, and the unique and interactive relations of these variables on distress.

Notwithstanding, there were several limitations of this study. Because a large number of analyses were conducted, some findings may be significant only by chance. Regressions predicting symptoms were exploratory, presented in the hope of stimulating future research, and replication will be essential. Because power to find moderators is weak in regression analyses involving non-experimental measures (McClelland & Judd, 1993), non-significant interactions should be interpreted with as much caution as significant interactions. Although results suggest an important relationship between attentional bias, stress, temperament, and distress, direction of influence cannot be determined with these correlational results. The causal relationship between attentional bias and emotional responses to stress has been investigated experimentally by training participants to attend to neutral or emotional stimuli and then measuring responses to a stressful task (MacLeod et al., 2002). The results indicate that attentional training can influence emotional responses to stress, supporting the notion that understanding individual differences in the capacity to regulate attentional allocation will be important for increased understanding of the causal relationship between attention and distress.

Finally, two additional limitations are inherent to the design of the dot probe task. The first arises from a design in which subliminal and supraliminal cues were presented randomly, which did not permit investigation of order effects related to exposure duration. Supraliminal threat cue priming may affect subsequent sub-liminal and supraliminal attentional patterns, as well outcomes and coping associated with biases (Luecken et al., 2004). Conscious attempts to divert attention from supraliminal cues may make these cues hyperaccessible at the subliminal level (Dejonckheere, Braet, & Soetens, 2003; Wegner, 1994). Second, although a 1250 ms interval between word pair presentation and target appearance is standard in studies of attentional bias studies in children, in college students, it is sufficiently long to allow movements of attention between the two stimulus words (Reed & Derryberry,

1995). Assuming the same is true for children, it is not possible to separate the impact of orientation to threat cues from the impact of difficulty disengaging from threat cues.

On a related note, additional research should be devoted to exploring potential differences between adults and children in the causes and consequences of attentional biases, particularly at the supraliminal level. Although the underpinnings of trait attentional control are present early in life and maintained across the lifespan (Rothbart et al., 1995), capacity to effortfully regulate attention improves from childhood to adulthood. In addition, individuals may become more sophisticated with life experience about the personal costs and benefits of attending to threat cues. Thus, relations between stress, temperament, attentional processes, and psychological outcomes may differ across the lifespan. Past studies do not suggest a clear pattern of age differences, and the few directly comparing children and adults suggest that attentional processes are similar across age groups (e.g., Bar-Haim et al., 2007; Waters, Lipp, & Spence, 2004). However, this issue requires nuanced consideration, as the study of developmental changes in attention may help to explain the origin of attentional biases and suggest intervention strategies to prevent or alter harmful attentional patterns.

A growing body of literature indicates that both automatic and volitional attentional processes influence affective outcomes. Attentional allocation toward or away from threat is a dynamic process, in which external threats are processed according to their current relevance, and dispositional factors guide both the nature and impact of attentional bias. The results support the notion that vigilance to subliminal threat is likely to be harmful, although that harm may only be manifested in individuals facing a high degree of stress or for those with temperamental vulnerabilities for distress. The impact of supraliminal vigilance to threat is less clear, and the possibility exists that documented effects of supraliminal attentional bias on distress may be due to initial subliminal orientation rather than to extended exposure in the supraliminal paradigms. The exploratory analyses presented here suggest a need for further evaluation of ways in which stress level and temperament may influence the costs and benefits of vigilance to consciously perceived cues. Examination of these processes will further basic knowledge about the dynamic interplay between non-conscious and conscious processing, as well as lead to better understanding of the relationship between the cognitive and emotional realms.

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