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Threat-Related Attentional Bias in Anxious and Nonanxious Individuals: A Meta-Analytic Study

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This meta-analysis of 172 studies (N = 2,263 anxious, N = 1,768 nonanxious) examined the boundary conditions of threat-related attentional biases in anxiety. Overall, the results show that the bias is reliably demonstrated with different experimental paradigms and under a variety of experimental conditions, but that it is only an effect size of $d = 0.45$. Although processes requiring conscious perception of threat contribute to the bias, a significant bias is also observed with stimuli outside awareness. The bias is of comparable magnitude across different types of anxious populations (individuals with different clinical disorders, high-anxious nonclinical individuals, anxious children and adults) and is not observed in nonanxious individuals. Empirical and clinical implications as well as future directions for research are discussed.

Keywords: attentional bias, selective attention, anxiety, threat

A normative function of the mechanisms underlying fear is to facilitate detection of danger in the environment and to help the organism respond effectively to threatening situations. Biases in processing threat-related information have been assigned a prominent role in the etiology and maintenance of anxiety disorders (A. T. Beck, 1976; Eysenck, 1992; Mathews, 1990; Mathews & MacLeod, 2002; Williams, Watts, MacLeod, & Mathews, 1988). Specifically, several authors have suggested that the attentional system of anxious individuals may be distinctively sensitive to and biased in favor of threat-related stimuli in the environment. Over the last 2 decades, this notion has fostered intensive research on attentional biases in anxiety using different experimental tasks both in clinical populations displaying a variety of anxiety disorders and in nonclinical individuals reporting high levels of anxiety.

Although several narrative reviews have been published on topics related to processing biases in anxiety, they were typically selective in nature. Some reviews have focused on processing biases in selected populations, such as in individuals experiencing posttraumatic stress disorder (PTSD; Buckley, Blanchard, & Neill, 2000), social phobia (Clark & McManus, 2002; Heinrichs & Hofman, 2001; Musa & Lepine, 2000), obsessive–compulsive disorder (OCD; Summerfeldt & Endler, 1998), generalized anxiety disorder (GAD; Mogg & Bradley, 2005), or panic disorder and phobias (McNally, 1999), or in children (Ehrenreich & Gross, 2002). Other reviews have focused on specific issues within the field, such as processing biases in anxiety versus depression (Dalgleish & Watts, 1990; Mineka & Gilboa, 1998), nonverbal information processing in anxiety (Mogg & Bradley, 2003), or processing biases in anxiety as measured specifically by the emotional Stroop paradigm (MacLeod, 1991; Williams, Mathews, & MacLeod, 1996). Other work has revolved on the literature relevant to testing a specific model of threat processing in anxiety, such as Mogg and Bradley's (1999b) cognitive-motivational model, Fox's (2004) review on maintenance versus capture of attention in anxiety-related biases, or Mansell's (2000) top-down model of processing biases in anxiety. The field lacks, however, an updated encompassing and systematic review. In addition, there has not been a single quantitative review of the considerable amount of available data assessing the overall effect size and the influence of the major moderators related to threat processing in anxiety. For in-depth discussions of the advantages inherent in meta-analysis versus narrative reviews, see Cooper and Hedges (1994) and Cooper and Lindsay (1998). Therefore, the objective of the present meta-analysis was to assess the magnitude and boundary conditions of threat-related biases in anxiety by organizing the extant database according to variables identified as potential modulators of the phenomenon.

Theories of Cognitive Biases in Anxiety

Cognitive accounts of anxiety differ with regard to the roles they assign to biases in attention, interpretation, memory, and judgment in the etiology and maintenance of anxiety. According to schema theories (e.g., A. T. Beck, 1976; A. T. Beck & Clark, 1997; A. T. Beck, Emery, & Greenberg, 1985; Bower, 1981, 1987) cognitive processing is guided by schemas that largely determine how information is attended to, interpreted, and remembered. In anxious individuals, schemas are thought to be biased toward threat. As a result, threat-related material is favored at all stages of processing,

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including early processes such as attention and stimulus encoding and later processes such as memory and interpretation.

Other theories suggest that anxious individuals are prone to biases at specific stages of information processing. Some authors have proposed that the attentional system of anxious individuals is abnormally sensitive to threat-related stimuli and that these individuals tend to direct their attention toward threatening information during early, automatic stages of processing (Williams et al., 1988). This idea is consistent with the literature showing that evaluation of stimulus emotional valence may take place at a very early stage of processing, automatically, and in the absence of awareness (e.g., LeDoux, 1995, 1996; Ohman, 1993). Abnormalities in the threat-detection mechanism of anxious individuals would therefore lead them to adopt a hypervigilant mode toward threat. A quite different proposal is that inhibition of detailed processing of threatening information is the core deficit in anxiety, which is reflected in avoidance of threatening stimuli (Foa & Kozak, 1986; Mogg, Bradley, De Bono, & Painter, 1997). According to this view, threat-related biases in anxiety are confined to later stages of processing.

More recent models have suggested a more complex pattern of biases that may reconcile these apparently conflicting views. They have emphasized the time course of attentional allocation in maintaining high levels of anxiety (e.g., Clark & Wells, 1995; Eysenck, 1992; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Williams, Watts, MacLeod, & Mathews, 1997).

Williams et al. (1997, 1988) and others (see Amir, Foa, & Coles, 1998; Mogg et al., 1997) have proposed that anxious individuals tend to direct their attention toward threat during early, automatic stages of processing, whereas during later, more strategic stages of processing, they tend to direct their attention away from threat. Automatic allocation of attentional resources to threat-related stimuli would serve to enhance an individual's anxious state, yet subsequent avoidance of such stimuli would prevent more elaborate evaluation processes that could deflate the threatening value of these stimuli and thereby reduce anxiety.

Other research groups (e.g., Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002; Yiend & Mathews, 2001) have suggested that anxiety has little impact on initial detection of threat but has a stronger effect in modulating the maintenance of attention on the source of threat. That is, they have proposed that a delay in disengaging from threat stimuli might be the primary attentional difference between anxious and nonanxious individuals.

Despite disagreements as to the specific cognitive mechanisms underlying anxiety, there is a consensus at the theoretical level that anxiety is associated with biases in attending to threat-related information. However, at the empirical level, the wide range of studies concerned with threat-related biases in anxiety offers a somewhat confusing picture, plagued by contradictory findings that lack unambiguous explanation. In the next section, we describe potential factors contributing to the divergence of empirical findings and their interpretation in the field.

Operational Considerations in the Study of Attentional Bias in Anxiety

Part of the confusion regarding the empirical findings may be traceable to the fact that two different operational definitions of *bias* are used in the literature but do not necessarily converge. The first definition refers to a significant difference in the attentional allocation of highly anxious individuals with respect to threat-related stimuli relative to neutral stimuli (a within-subject bias). The other definition refers to a significant difference between anxious and nonanxious individuals in the pattern of attentional allocation to threat-related and neutral stimuli (a between-subjects bias).

Anxious individuals are sometimes found to attend preferentially to threat-related stimuli relative to neutral stimuli (within-subject bias) but not significantly more so than control participants (e.g., Kyrios & Iob, 1998). Such findings imply a threat-related bias that does not specifically characterize anxious individuals (no between-subjects bias). Conversely, a significant difference in the attentional allocation pattern of anxious individuals relative to nonanxious controls (between-subjects bias) is sometimes reported, while at the same time, anxious individuals show no significant tendency to allocate their attention to threatening relative to neutral material (no within-subject bias). This pattern of results may arise, for example, when anxious participants show a nonsignificant attentional bias toward threat whereas control participants show a bias away from threat (e.g., Musa, Lepine, Clark, Mansell, & Ehlers, 2003; Stewart, Conrod, Gignac, & Pihl, 1998). Yet, in both instances of divergence between the within-subject and between-subjects definitions of the bias, the finding that is consistent with the idea of anxiety's being associated with a threat-related attentional bias has most often been put forward, which contributes to the impression that the threat-related bias in anxious individuals is large and robust.

In addition, studies of the threat-related bias in anxiety usually differ along a wide array of variables, with positive findings of an attentional bias often being found in one of the relevant experimental conditions but not in others within the same study. The myriad of variables used in studies of threat-related biases in anxiety can be grouped under two broad categories: procedural variables and population-related variables.

With regard to procedural variables, the threat-related bias has been measured using different paradigms, namely, the emotional Stroop, dot-probe, emotional spatial cuing, and visual search paradigms. Although there is strong evidence that all these paradigms reflect the operation of attentional processes (e.g., Driver, 2001), it is also generally accepted that they do not tap the same aspects of attention (e.g., Shalev & Algom, 2000). In addition, studies have differed in the types of stimuli used, either printed words or pictorial stimuli. Finally, the threat-related bias has been examined in conditions that prevented conscious perception (subliminal exposure) and in conditions that allowed clear awareness (supraliminal exposure). Processes triggered by signs of threat that are perceived with or without awareness might yield different behavioral outcomes. In addition, with consciously perceived stimuli, attentional effects have been measured at various times after stimulus presentation. Given the debate concerning the notions of hypervigilance versus avoidance of threat in anxiety, the time course of attentional allocation to threat-related stimuli is important, because different time frames are likely to yield different results.

With regard to population-related variables, anxious participants have been sampled from populations that varied considerably from one study to another. Some studies have examined adults, whereas others have examined children. Participants either were diagnosed with clinical anxiety (clinical population) or only scored high on questionnaires relying on self-report of either state or trait anxiety (nonclinical population). Moreover, clinically diagnosed participants differed in the type of anxiety disorder they experienced, namely, GAD, specific phobias, social phobia, OCD, PTSD, and panic disorder. Whether these participants concomitantly experienced depression was often reported yet seldom controlled for.

Thus, in view of the numerous experiments with diverging results, a quantitative test of the overarching conclusions typically drawn as to the existence of a threat-related bias in anxious individuals is in order. We now turn to a more detailed description of the different moderators considered in this meta-analysis.

Procedural Moderators

Subliminal Versus Supraliminal Stimulus Presentation

Research on the neural substrates of emotion has underscored the role of automatic processes in mediating anxiety and fear responses (e.g., LeDoux, 1996; Ohman, 1993). Specifically, it has been suggested that neural structures sensitive to signs of biologically threat-relevant stimuli can directly trigger anxiety responses and draw attention toward the source of threat before conscious perception and evaluation occur. Most studies of the threat-related bias in anxiety have involved clearly visible stimuli, typically presented for 500 ms or longer, an exposure time that allows the stimuli to be consciously perceived. However, in a number of studies the critical stimuli were presented in conditions that precluded conscious processing. In these studies, the stimuli were typically presented for very brief durations (subliminal exposure) and were immediately masked. Such backward masking is known to interrupt sensory processing, thereby preventing the masked stimuli from reaching awareness (e.g., Di Lollo, Enns, & Rensink, 2000). The rationale for using subliminal stimuli is that the structures underlying early, automatic, rather than later, conscious processing of threat may be abnormally sensitive in anxious individuals.

Finding a threat-related bias in response to supraliminal stimuli does not allow a distinction between the contributions of a preconscious bias versus a bias that requires awareness of the threatening stimulus. Finding a bias using subliminal stimuli can be accounted for only by an early, preconscious bias.

Experimental Paradigms

Three main experimental paradigms have been used to study the threat-related attentional bias in anxiety: emotional Stroop, dot-probe, and emotional spatial cuing. In the following paragraphs, we describe these paradigms and the different theoretical implications that arise from the use of each of them. Surprisingly, the *visual search paradigm*, a primary tool used to investigate attentional priority when several objects compete for attention, has been only seldom used in the context of anxiety research (cf. Gilboa Schechtman, Foa, & Amir, 1999; Hadwin et al., 2003; Rinck, Becker, Kellermann, & Roth, 2003). Thus, a meta-analysis of these studies would be premature.

The *emotional Stroop* is a modified version of the classic color-naming Stroop interference paradigm (Stroop, 1935). The *Stroop effect* refers to the difference in color-naming performance between congruent (e.g., the word *red* printed in red) and incongruent (e.g., the word *red* printed in green) stimuli. The presence of the Stroop effect documents the failure to focus exclusively on the target dimension of color. In the emotional Stroop, the word valence instead of its semantic congruence with the printed color is manipulated. For instance, response latency to name the printed color of a word is compared when this word is threat related (e.g., "*cancer*") relative to when it is neutral (e.g., "*plate*"). When pictures instead of words are used, the participant might be required to name the color of a schematic face, with this face displaying either a neutral or an angry expression. Threat-related bias is inferred when color naming takes longer with a threat stimulus relative to a neutral stimulus (MacLeod, 1991).

The emotional Stroop was initially the most widely used tool to investigate threat-related attentional biases in anxiety. However, it has been criticized with the argument that delayed response latencies with threat-related stimuli may result from late processes that are unrelated to attention (e.g., Algom, Chajut, & Lev, 2004; MacLeod, Mathews, & Tata, 1986). MacLeod et al. (1986) suggested that anxious participants might process both the neutral and the threat-related meanings to the same degree but that the presence of the latter might intensify the negative affective state of anxious participants to a level where it impairs reaction time. De Ruiter and Brosschot (1994) further suggested that interference by threat stimuli in the emotional Stroop might reflect effortful avoidance of processing threat cues rather than attentional capture by these cues.

To overcome these problems MacLeod et al. (1986) designed the *dot-probe paradigm*. In this task, two stimuli, one threat-related and one neutral, are shown briefly on each trial, and their offset is followed by a small probe in the location just occupied by one of them. Participants are required to respond as fast as possible to the probe. On the basis of the attention literature (e.g., Navon & Margalit, 1983), response latencies on the dot-probe task are held to provide a "snapshot" of the distribution of participants' attention, with faster responses to probes presented in the attended relative to the unattended location. Attentional bias toward threat is revealed when participants are faster to respond to probes that replace threat-related rather than neutral stimuli.

In the dot-probe paradigm, participants are required to respond to a neutral stimulus (the probe). Therefore, there is no concern that delayed latencies may result from response bias or general arousal. An additional advantage of this paradigm is that manipulating *stimulus onset asynchrony*, that is, the time interval between presentation of the critical stimuli and presentation of the probe, allows for investigating the time course of attentional allocation.

In the dot-probe paradigm, the advantage in performance on trials in which the target probe appears at the location of the threat-related stimulus might result either from faster engagement with the threat stimulus or from a difficulty to disengage from it. In order to determine the relative contributions of these two components of attention (Posner & Peterson, 1990) to the threat-related attentional bias, a variant of Posner's spatial cuing paradigm has been used. In Posner's classical paradigm (Posner, 1980), a cue appears in one of two locations and is followed by a target presented at the cued location on a majority of the trials (valid-cue condition) and at the alternative location on a minority of the trials (invalid-cue condition). Performance in detecting or identifying the target is typically faster on validly cued than on invalidly cued trials. Speeding on validly cued trials has been attributed to the benefits of attentional engagement with the cued location. Slowing on invalidly cued trials has been associated with the costs of having to disengage attention from the cued location.

Stormark, Nordby, and Hugdahl (1995) adapted this paradigm to the study of attentional allocation to emotionally valenced stimuli by manipulating the emotional content of the cue. Fox et al. (2001) later used the *emotional spatial cuing paradigm* to investigate attentional bias related to threat in anxiety. A threat-related attentional bias is revealed when validity effects (performance on invalid-cue trials minus performance on valid-cue trials) are larger when the cue is threat related than when it has a neutral content. Moreover, a valence-related modulation of performance on valid-cue trials indicates that the attentional bias occurs at the stage of initial orienting of attention, whereas such modulation on invalid-cue trials reflects a difficulty in disengaging attention from threat-related material after attention has been engaged. Unfortunately, the small number of studies that have distinguished between the "engage" and "disengage" components of attention, and the fact that these components were invariably examined in within-subject designs, precluded meta-analytic examination of this issue.

As with the dot probe, in the emotional spatial cuing paradigm the target to which subjects respond is neutral with respect to valence. Thus, this paradigm is not open to the alternative account of response bias in anxious participants. However, unlike the dot-probe paradigm, in which the neutral and threat-related stimuli compete for the participants' attention, in the emotional spatial cuing paradigm the visual field contains just one stimulus. To the extent that competition among different stimuli might be a prerequisite for threat-related attentional bias in anxiety to emerge, the dot-probe task might be a more sensitive paradigm. Moreover, whereas in the dot-probe paradigm, the valenced cue stimuli are utterly task irrelevant, in the emotional spatial cuing paradigm participants are instructed to attend to the valenced cue (through validity instructions). This fact may hamper the generalizability of the findings generated by the emotional spatial cuing paradigm, as these might be contingent on the cue stimulus's being task relevant.

Words Versus Naturalistic Stimuli

Threat-related bias in anxiety has been initially investigated using word stimuli, the meaning of which was either threat related or neutral. Reliance on verbal stimuli was criticized on several grounds (e.g., Bradley et al., 1997). It is likely that anxious individuals spend more time than nonanxious individuals thinking about threatening events or speaking with others about their anxious feelings. As a result, the very words used as threat stimuli are likely to be more primed in anxious participants than in nonanxious control participants. Thus, the valence-related effects observed with words may reflect high familiarity and subjective frequency of use of the threat words rather than a threat-related attentional bias (McNally, Riemann, & Kim, 1990).

Threat-related and neutral pictures have been used to corroborate the findings obtained with word stimuli. The most widely used pictorial stimuli are human faces displaying emotion expressions. Recognition of facial expression is automatic and does not require conscious awareness (e.g., Morris, Ohman, & Dolan, 1998). Such rapid recognition is highly adaptive: A threatening face is a clear sign of danger and should therefore be a good candidate for capturing the attention of anxious individuals. Angry and fearful faces fall into the category of threat-related stimuli, whereas neutral or happy faces are typically used as control stimuli.

Population-Related Variables in the Study of Threat-Related Bias in Anxiety

Clinically Diagnosed Anxiety Versus Nonclinical Self-Reported Anxiety

The attentional bias in anxiety has been investigated in individuals with diagnosed anxiety disorders (clinical population) and in individuals who self-reported high levels of anxiety on questionnaires (nonclinical population). As clinical participants typically display more severe anxiety, it is reasonable to expect that they will show larger attentional biases. In addition, some authors have claimed that even with similar levels of reported anxiety, clinical participants should display a larger bias due to qualitative differences between clinical and nonclinical anxiety (e.g., Martin, Williams, & Clark, 1991).

One should keep in mind, however, that in between-subjects analyses (anxious vs. control) for clinical versus nonclinical populations, control participants for the nonclinical populations are often selected for particularly low anxiety scores, whereas controls for clinical participants are a matched sample, usually selected from the general population.

Threat-related biases have been investigated in a variety of clinical anxiety disorders (e.g., GAD, PTSD, social phobia, simple phobias, OCD, panic disorder). Although the different disorders present considerable differences in symptoms, time course, etiology, and prognosis, they are typically held to belong to the same overarching family of anxiety disorders. Finding that the threat-related attentional bias is reliably detected in each of these disorders would reinforce the idea that attentional bias is a core component of anxiety. In contrast, if the attentional bias is not reliably demonstrated in one or more of the disorders, this may be interpreted as a divergence of this particular disorder from the family of anxiety disorders (see the discussion regarding OCD in Summerfeldt & Endler, 1998).

Effect of Depression Comorbidity

Anxiety and depression are frequently comorbid conditions (e.g., Mineka, Watson, & Clark, 1998). Despite common features such as high levels of negative affect and distress, the two conditions also present unique features such as exacerbated fear of danger in anxiety and thoughts of failure and worthlessness in depression. With regard to cognitive biases, it has been suggested that anxiety is associated with an attentional bias toward threat and depression is associated with greater elaboration of negative material (Williams et al., 1997). Accordingly, patients with depression do not generally show an attentional bias toward negative information and appear to do so only with long stimuli exposures that allow later, elaborative processing to occur (Eizenman et al., 2003; see Mogg & Bradley, 2005, for an extensive review).

It is not clear at this point how anxiety and depression interact on measures of attentional bias. On the one hand, if depression-related effects are revealed only at later stages of processing, then comorbidity of depression might not affect the attentional bias in anxiety. On the other hand, there have been reports that when clinical anxiety and depression coexist, the attentional bias is no longer found (e.g., Mogg, Bradley, Williams, & Mathews, 1993). Mogg, Bradley, and Williams (1995) suggested that the attentional bias in anxiety may reflect an individual's readiness to orient toward negative stimuli in order to deal with potential threats, that is, a motivational state. They further reasoned that depression is an amotivational state, and that depression comorbidity might therefore inhibit the motivation-based selectivity that characterizes anxiety. Thus, assessing the potential effects of participants' depression comorbidity may be of crucial importance for studies of threat-related bias in anxiety. In practice, however, many studies have failed to either report participants' depression levels or to covary them out from the attentional bias effect.

State Versus Trait Anxiety

Threat-related attentional bias in anxiety has been investigated mainly for trait anxiety and more seldom for state anxiety. Very few studies have directly compared the effects of state versus trait anxiety on the attentional bias. Some of these have examined which, of state or trait anxiety scores, were best correlated with attentional bias scores in clinically anxious individuals (e.g., Mathews & MacLeod, 1985; Mogg, Mathews, & Weinman, 1989). Others have used nonclinical participants differing in levels of trait anxiety and either experimentally induced state anxiety (e.g., Richards, French, Johnson, Naparstek, & Williams, 1992) or took advantage of naturally occurring stressful events (e.g., MacLeod & Rutherford, 1992). These studies have yielded conflicting findings and have led to various proposals as to the relative roles of state and trait anxiety in the attentional bias. For instance, Broadbent and Broadbent (1988) suggested that the two factors interact, with the effect of state anxiety being substantially larger in individuals with high trait anxiety than in individuals with low trait anxiety. A somewhat different proposal is that whereas state anxiety and the attentional bias are positively correlated in individuals with high trait anxiety, they are negatively correlated in individuals with low trait anxiety (Egloff & Hock, 2001). Others suggested that both transient stress (irrespective of trait anxiety) and enduring anxious personality characteristics (irrespective of state anxiety) are sufficient to produce the attentional bias (Mogg, Mathews, Bird, & Macgregor-Morris, 1990). Thus, how state and trait anxiety contribute to threat-related attentional bias remains an unresolved issue. In the present meta-analysis we compared the effect sizes of studies using state versus trait anxiety as the grouping variable of anxiety, but we did not examine the interaction between the two factors because of a lack of studies directly tackling this issue.

Children Versus Adult Participants

Because anxiety is highly prevalent in children and adolescents (Albano, Chorpita, & Barlow, 2003), and because continuity of trait anxiety from childhood to adulthood has been widely documented (e.g., Feehan, McGee, & Williams, 1993; Ferdinand & Verhulst, 1995; Pine, Cohen, Gurley, Brook, & Ma, 1998), there is clear theoretical and practical significance to the study of developmental aspects of the threat-related bias in anxiety. Surprisingly, however, only a small number of studies have been published with children relative to the extensive research with adults.

The conflicting findings in the extant literature have given rise to different proposals as to the developmental course of the association between processing biases and anxiety. For instance, Kindt and colleagues (Kindt, Bierman, & Brosschot, 1997; Kindt, Brosschot, & Everaerd, 1997) have suggested that both anxious and nonanxious young children show equal bias with respect to threat-related stimuli, and that whereas nonanxious children learn to inhibit this bias with increasing age, anxious children do not. According to this view, a significant attentional bias is expected in both anxious and nonanxious young children (Kindt & van den Haut, 2001). Others (e.g., Martin, Horder, & Jones, 1992) have proposed that threat-related attentional biases and anxiety go hand in hand from very early on in life. Because of the relatively small number of studies and the lack of longitudinal research, the present meta-analysis only allowed us to compare the effect sizes of studies with children versus adults on some of the studied moderators.

With the aforementioned considerations in mind, the purposes of the present meta-analysis were as follows: First, we wanted to assess the overall effect size of the attentional bias in anxiety in the literature to date and to determine whether the bias is smaller, absent, or away from threat in nonanxious participants. Second, we wanted to provide a systematic evaluation of the effects of the major variables along which the existing studies on attentional bias in anxiety differ. With respect to procedural variables, we examined whether subliminal stimuli exposure times result in smaller effect sizes than supraliminal stimuli exposure times, whether or not divergent results are found for the various paradigms, and whether naturalistic pictures produce a stronger bias than word stimuli. With respect to population-related variables, we examined whether clinically anxious participants display a larger bias than high-anxious participants recruited from normative populations, whether or not the bias is characteristic of all anxiety disorders, and whether effect sizes for threat-related bias in anxious children and adolescents are similar to those in anxious adults. The third purpose of the present study was to use the meta-analytic tool to generate new findings by analyzing interactions among the different moderators, whether procedural or population related.

Method

Literature Base

Studies were collected through a search of the PsycInfo and PubMed databases using the key words *attention**, *bias**, *selective attention**, *Stroop*, *dot-probe*, *probe detection*, *Posner*, *spatial cueing*, *or visual search*, intersected with *anxi** (anxiety), *phob** (phobia), *PTSD*, *OCD*, *panic*, or *GAD*. In addition, these databases were searched with the names of researchers in the field to see whether there were additional relevant publications from these authors. The references of all the obtained articles as well as of relevant review articles (e.g., Dalgleish & Watts, 1990; Mogg & Bradley, 1999b; Williams et al., 1996) were systematically searched for additional relevant studies.

Inclusion Criteria

We used the following criteria to select studies for inclusion in the meta-analysis:

1. The study was published as a journal article in the English language until May 2005.

2. The study used one of the following experimental paradigms: emotional Stroop, probe detection (or dot-probe) task, or a version of the emotional spatial cuing task. There were insufficient visual search studies meeting the inclusion criteria as outlined later to allow systematic analysis.

3. The difference between threat-related and neutral stimuli could be assessed. Studies that compared threat-related stimuli with stimuli other than neutral (e.g., Mathews & MacLeod, 1985, who contrasted reactions to negative stimuli with a combination of positive and neutral stimuli) were excluded from the meta-analysis. Differences between threat-related stimuli and other emotionally valenced stimuli render the source of the bias unclear, because the observed behavior could stem from a bias related to the threat stimulus or from a bias related to the other emotionally valenced stimulus, or from a combination of both. It should be noted that this selection criterion precludes a distinction between the effects of threat in particular versus emotion in general. The investigation of that distinction calls for a separate set of meta-analyses comparing neutral versus emotional non-threat stimuli, which is beyond the scope of the present study. Similarly, studies comparing threat-related words to nonwords (e.g., McNally, Riemann, Louro, Lukach, & Kim, 1992) were excluded because an observed bias in such studies might stem from a difference in semantic versus nonsemantic processing rather than from the valence of the threat word.

4. The study included a group of anxious participants selected on the basis of either clinical diagnosis or self-reported high anxiety on a questionnaire. Studies that formed anxiety groups based solely on experimental manipulations inducing anxiety in normative samples (e.g., Green, Rogers, & Elliman, 1995) were excluded because the anxiety-inducing procedures differed considerably between studies and were typically not validated by reliable manipulation checks.

5. The study reported data that allowed the computation of an effect size for at least one of the following outcome measures of attentional bias: a within-group comparison for anxious participants, a within-group comparison for control participants, or a between-groups comparison. The within-group effects refer to the bias measured as the difference between threat-related and neutral conditions reported by statistics such as t or F values. The between-groups effect refers to the bias measured as the difference between the anxious and control groups on the aforementioned effect, reported with between-groups statistics such as t or F values, or sometimes as a correlation between the bias score and the anxiety score on a questionnaire.

6. In cases in which an effect was reported as nonsignificant but exact statistics were not provided, we calculated an estimated effect size assuming $p = .50$, in order to ensure a representative sample of outcomes (Cooper & Hedges, 1994). This procedure was used only when enough information was provided (e.g., tables, figures) to determine the direction of the effect, and it was used in 25.6% of the between-groups outcomes, in 17.9% of the within-anxious-group outcomes, and in 40.2% of the within-control-group outcomes.

The listed criteria resulted in the selection of 172 studies (including 4,031 participants in total), published between February 1986 and May 2005.

Coding System and Coding Decisions

We used a standard coding system to rate every study (see Table 1). We coded sample size (N), whether the participants were children under 18 years of age or adults (age group), and whether the anxious group was clinically diagnosed or included participants with high self-reported anxiety (anxiety type). For clinical samples we noted the type of anxiety disorder, and for self-reported anxiety, we noted the type of anxiety measure used. We coded whether participants with comorbid mood disorder were included or excluded from each sample (mood disorder comorbidity).

We coded the type of paradigm used (i.e., emotional Stroop, dot probe, or emotional spatial cuing) and the type of stimuli presented in the experiment (stimulus type; i.e., words or pictures). We also took into account whether the stimuli in the emotional Stroop paradigm were presented in a blocked design (i.e., stimuli from different categories presented within different blocks of trials) or randomly (emotional Stroop design). Finally, to assess the effect of stimulus exposure time, we coded whether the stimuli were presented with subliminal or supraliminal exposure. Because several dot-probe studies were theoretically concerned with the effects of various supraliminal exposure times, we created a more detailed exposure time moderator variable for dot-probe studies (subliminal, 500 ms, and 1,000 ms or longer).

Some additional coding decisions were made:

1. To enhance the power of moderator analyses, in studies in which participants were tested on more than one level of a moderator variable (e.g., participants were presented with both word and picture stimuli), we selected the level that included fewer overall samples for analysis. Specifically, we selected subliminal over supraliminal exposure times, state over trait anxiety, the dot-probe paradigm over the emotional Stroop paradigm, and picture stimuli over word stimuli. In dot-probe studies not reporting subliminal exposure times, we preferred longer exposures (1,000 ms or longer) over exposures of 500 ms.

2. When data for the same participants were reported in two different studies, only one study was selected based on the criteria just mentioned.

3. If a single control group was compared with two or more anxiety groups within the same study, the number of control participants in the reported analyses was split accordingly to avoid inflation of the number of participants.

4. When a study assigned participants to more than two groups of anxiety level (e.g., low, medium, and high anxiety), we selected the two extreme groups.

5. When different intensity levels of threat stimuli were used in one study (e.g., mild threat and high threat), we calculated an effect size that reflected the average of the two conditions. Although different theories postulate different assumptions concerning the effect of threat level on the magnitude and direction of bias in anxious and in control participants (for a discussion on this topic, see Mogg, McNamara, et al., 2000; Wilson & MacLeod, 2003), most studies have used only one level of threat, and levels of threat are hardly comparable across studies. Thus, when mild- and high-threat stimuli are used in the same study, it is practically impossible to determine which of the two threat levels is more compatible with the "'single"' level of threat stimuli used in other studies. For these reasons, we chose to average the effects of different intensities of threat instead of choosing one over the other.

Table 1
Coding System for Individual Studies

Variable	Coding description
Population	
N anxious	Sample size for which a within-anxious-group effect is reported
N control	Sample size for which a within-control-group effect is reported
Age group	0 = children (under 18 years of age)
	1 = adults
Anxiety type	0 = clinically diagnosed disorders
	1 = high self-reported anxiety
Type of anxiety disorder	0 = generalized anxiety disorder
	1 = obsessive–compulsive disorder
	2 = panic disorder
	3 = post-traumatic stress disorder
	4 = social phobia
	5 = simple phobia
Type of anxiety measure	0 = trait anxiety (State-Trait Anxiety Inventory)
(self-reporting samples)	1 = state anxiety (State-Trait Anxiety Inventory)
	2 = other
Mood comorbidity	0 = participants with comorbid mood disorder were excluded
	1 = participants with comorbid mood disorder were included
Experimental procedure	
Paradigm	0 = emotional Stroop
	1 = dot probe
	2 = modified Posner
Exposure time, general	0 = subliminal
	1 = supraliminal
Exposure time, dot probe	0 = subliminal
	1 = 500 ms
	2 = ≥1,000 ms
Stimulus type	0 = words
	1 = pictures
Stroop design	0 = blocked
	1 = random

6. When more than one type of threat-related stimuli were presented (e.g., physical threat and social threat) the type of threat most congruent to the studied anxiety group was selected (e.g., for participants with social phobia, we selected the social threat data over the physical threat data). In cases in which two threat categories were equally relevant to the studied group of participants, we calculated an effect size that reflected the average of the two effects. For example, Brosschot, de Ruiter, and Kindt (1999) studied the threat-related bias in high- and low-trait-anxious participants, who were presented with social threat words and physical threat words, both equally relevant to the general concept of trait anxiety. Thus, the average of the two effect sizes was computed for further analyses.

7. When studies involved therapy or any kind of experimental manipulation and measured selective attention to threat before and after the manipulation, we included the data emanating from the pretest measurement.

Intercoder reliability for the moderator variables was established on 15% of the articles included in the meta-analysis. Across the total variable matrix, kappas ranged from .69 to 1.00 (the mean kappa was .96). Disagreements were resolved by discussion, and the final coding reflected the consensus between the two coders.

Meta-Analytic Procedures

The effect size index we used for all outcome measures in the present meta-analysis is Cohen's *d*, that is, the difference between the means of two conditions or groups divided by their pooled standard deviation. For the within-group analyses, a positive sign of the effect size value indicates that attention is biased toward threat-related stimuli. For the between-groups analyses, a positive sign of *d* indicates that the attentional bias toward threat is larger in anxious participants than in control participants. All analyses and computations were carried out using Comprehensive Meta-Analysis software, Version 2.002 (Biostat, Englewood, NJ).

Because most of our data sets were heterogeneous in their effect sizes, and because random effects models are somewhat more conservative than fixed effects parameters in such cases, combined effect sizes and their confidence intervals (CIs) are presented in the context of random effects models. For a detailed discussion of this issue, see Bakermans-Kranenburg, van IJzendoorn, and Juffer (2003).

Screening the entire data set for outliers revealed one study (Vasey, El Hag, & Daleiden, 1996) that yielded an effect size that was larger than 3 standard deviations from the group means of each of the major effect size categories used in this meta-analysis (within anxious group, within control group, and between groups), and was thus removed from further analyses. One additional study (Kyrios & Iob, 1998) yielded an effect size larger than 3 standard deviations from the mean effect size of the within-anxiety-group data, and this particular effect size was also excluded from further analyses. Therefore, the present meta-analysis was based on 172 samples reported in 142 journal articles. These 172 studies yielded 323 effects: 112 representing within-group attentional bias effects in anxious participants, 87 representing within-group attentional bias effects in control participants, and 124 representing between-groups differences in attentional bias between anxious and control groups. A table describing the 172 studies included in the meta-analyses may be obtained from us on request.

The results are organized into three main sections. In the first section, we focus on the effects of procedural variables, namely, stimulus exposure time, experimental paradigm, and stimulus type, and the interactions among them. In the second section, we describe effects of population-related variables, namely, clinical versus nonclinical anxiety, age, type of anxiety disorder, state versus trait anxiety, and mood disorder comorbidity, and the interactions among them. In the third section, we report interactions among the procedural and population-related moderators.

For each question, we assessed the magnitude of the combined within-anxiety-group effect, the combined within-control-group effect, and the difference between these two effects. In addition, we calculated the magnitude of the difference in threat-related bias between the anxious and control groups using the effect sizes of between-group comparisons. Together, these analyses provide a comprehensive view of the state of affairs regarding each of the pertinent questions. Table 2 provides combined within-group effect sizes, CIs, p values, number of studies (k), and number of participants (n) that were included in the analyses for the anxiety and control groups. Table 3 provides the same data for the between-groups analyses. For brevity reasons, only the essence of the findings concerning each of the focal questions is reported in the text. A full report of all statistics is provided in Tables 2 and 3.

Results

Overall Effect of Threat-Related Bias

Across all the studies that reported within-group effects, the combined effect size of the threat-related bias was significant in anxious participants ($k = 112$, $n = 2{,}263$, $d = 0.45$, $p < .01$, CI = 0.40, 0.49), and nonsignificant in nonanxious controls ($k = 87$, $n = 1{,}768$, $d = -0.007$, $p = .85$, CI = −0.06, 0.05). The difference between the combined effect sizes of anxious and control participants was significant ($Q = 87.56$, $p < .01$). Meta-analysis of the studies that reported between-groups comparisons ($k = 125$, $n = 2{,}963$ and $n = 2{,}906$ for anxious and control participants, respectively) indicated an overall difference between the two groups ($d = 0.41$, $p < .01$, CI = 0.34, 0.48) that was comparable to the within-group effect for anxious participants. Thus, a significant threat-related bias was present in anxious participants but not in nonanxious participants.

Procedural Moderators

Is Threat-Related Bias Stronger With Supraliminal Exposure Times Than With Subliminal Exposure Times?

The combined effect sizes of threat-related bias in anxious participants were significant both for studies using subliminal exposure times ($k = 20$, $d = 0.32$, CI = 0.20, 0.44) and for studies using supraliminal exposure times ($k = 90$, $d = 0.48$, CI = 0.42, 0.54). Although the combined effect size was slightly larger for supraliminal than subliminal exposures, this difference was not significant. Control participants showed no bias with either exposure time, and the combined effects for anxious participants were significantly larger than those for control participants with both exposure times. Consistent with this finding, the between-groups data revealed a significant difference between anxious and control participants for both exposure times (ks = 27 and 98, ds = 0.37 and 0.42, CIs = 0.22, 0.52, and 0.34, 0.50, for subliminal and for supraliminal exposures, respectively).

Does the Magnitude of Threat-Related Bias Vary as a Function of Experimental Paradigm (Emotional Stroop, Dot Probe, Emotional Spatial Cuing)?

Anxious individuals displayed a significant threat-related bias with each of the tested paradigms ($k = 70$, $d = 0.49$, CI = 0.43, 0.56, with emotional Stroop; $k = 35$, $d = 0.37$, CI = 0.28, 0.46, with dot probe; and $k = 7$, $d = 0.43$, CI = 0.23, 0.64, with emotional spatial cuing). Control participants did not show a bias with any of the paradigms. In addition, the combined within-subject effect sizes of anxious participants were significantly larger than those of control participants for each of the paradigms. The between-groups comparisons revealed a similar pattern for studies using the emotional Stroop ($k = 77$, $d = 0.45$, CI = 0.36, 0.54) and those using the dot-probe ($k = 44$, $d = 0.38$, CI = 0.26, 0.50) paradigm. By contrast, the combined between-groups effect size of studies using the emotional spatial cuing paradigm was not significant ($k = 4$, $d = 0.009$, CI = −0.38, 0.40). It should be noted, however, that the latter combined effect size was based on four studies, two of which came from Broomfield and Turpin (2005), who obtained negative validity effects (i.e., faster reaction times on invalid-cue relative to valid-cue trials). In conclusion, the dot-probe and emotional-Stroop paradigms were equally effective in uncovering the between-groups bias, and evidence from the emotional spatial cuing paradigm was equivocal.

Is the Threat-Related Bias Larger in Emotional Stroop Studies Using Blocked Versus Random Designs?

Although both blocked- and random-design emotional Stroop studies yielded significant effects of threat-related bias in anxious participants, blocked presentations produced a significantly larger combined effect size ($k = 31$, $d = 0.69$, CI = 0.60, 0.78) than did randomized presentations ($k = 30$, $d = 0.35$, CI = 0.26, 0.44). Of interest, a small but significant combined effect size was also found for control participants in studies using a blocked design ($k = 18$, $d = 0.21$, CI = 0.10, 0.31). Notwithstanding, the difference between anxious and nonanxious participants was significant for both presentation modes, as reflected by the contrasts between the within-group combined effects of anxious and control participants and by the between-groups analyses.

Do Threat-Related Picture Stimuli Yield Larger Bias Than Word Stimuli?

There was no difference between the combined effect sizes with word stimuli and picture stimuli. Both types of stimuli produced a significant threat-related bias in anxious participants ($k = 88$, $d = 0.46$, CI = 0.40, 0.52, for words; $k = 24$, $d = 0.43$, CI = 0.32, 0.54, for pictures) and no significant bias in nonanxious controls. There was a significant difference between anxious and control participants with both word stimuli and picture stimuli.

Experimental Paradigm × Exposure Times

Does the magnitude of threat-related bias differ as a function of exposure times in dot-probe experiments? In dot-probe experiments, anxious participants showed a significant threat-related bias with all exposure times ($k = 5$, $d = 0.65$, CI = 0.42, 0.88, for subliminal exposures; k = 18, d = 0.31, CI = 0.20, 0.43, for 500-ms exposures; and k = 7, d = 0.29, CI = 0.11, 0.47, for exposures ≥ 1,000 ms), with no difference among the three exposure conditions. However, subliminal exposures (k = 5, d = 0.65, CI = 0.42, 0.88) yielded a significantly larger effect than supraliminal exposures (500 ms and over, k = 25, d = 0.31, CI = 0.21, 0.40, Q = 4.12, $p < .05$). Nonanxious control participants did not show significant effects with supraliminal exposures (500 ms and ≥ 1,000 ms) but did show a significant bias away from threat with subliminal exposures (k = 4, d = −0.28, CI = −0.47, −0.09). In addition, the differences between anxious and control participants were significant for subliminal and 500-ms exposures but failed to reach significance with longer exposures (≥ 1,000 ms).

Does the magnitude of threat-related bias differ between subliminal and supraliminal exposure times in emotional Stroop experiments? Subliminal and supraliminal stimulus exposures revealed significant combined effect sizes in anxious individuals and nonsignificant combined effect sizes in controls. Here, the threat-related bias in anxious participants was significantly larger with supraliminal exposures (k = 55, d = 0.57, CI = 0.50, 0.64) than with subliminal exposures (k = 15, d = 0.23, CI = −0.10, 0.35).

Comparison between the emotional Stroop, dot-probe, and emotional spatial cuing paradigms with subliminal and supraliminal exposure times. No emotional spatial cuing study used subliminal exposures. Contrasting combined effect sizes between emotional Stroop studies and dot-probe studies with subliminal exposures in anxious participants revealed a larger combined effect size for dot-probe studies (Q = 7.20, $p < .01$). The same comparison with supraliminal stimulus exposures revealed a larger effect size for emotional Stroop studies than for dot-probe studies (Q = 8.85, $p < .01$). Contrasts involving the emotional spatial cuing paradigm were nonsignificant.

Stimulus Type × Exposure Times

Do threat-related pictures yield larger effects than threat-related words with supraliminal exposures? With supraliminal exposures, both words (k = 72, d = 0.51, CI = 0.44, 0.57) and pictures (k = 20, d = 0.38, CI = 0.26, 0.50) produced significant bias effects in anxious, but not in control participants. There was no difference in effect sizes between the two types of stimuli.

Do threat-related pictures yield larger effects than threat-related words with subliminal exposures? The findings with subliminal stimulus exposures were inconclusive. Analyses within the anxious group showed that subliminally presented pictures produced a significantly larger combined effect size (k = 4, d = 0.65, CI = 0.42, 0.89) than did subliminally presented words (k = 16, d = 0.24, CI = 0.15, 0.34). Surprisingly, the combined effect size of the between-groups comparisons was significant for words (k = 21, d = 0.42, CI = 0.24, 0.61), but not for pictures (k = 6, d = 0.19, CI = −0.17, 0.54). Unfortunately, there were not enough samples with subliminally presented pictures for control participants (k = 3) to allow a complete analysis of this matter.

Experimental Paradigm × Stimulus Type

Do threat-related pictures yield larger bias effects than threat-related words in studies using the emotional Stroop paradigm? Anxious participants showed a significant combined effect size with words (k = 66, d = 0.51, CI = 0.44, 0.58) and a nonsignificant combined effect size with pictures (k = 4, d = 0.24, CI = −0.02, 0.50). However, the difference between the two types of stimuli was nonsignificant. In control participants, the bias was not significant with words, and not enough emotional Stroop samples used pictures (k = 3).

The between-groups analyses revealed significant differences between anxious and control participants in emotional Stroop studies that used words (k = 71, d = 0.48, CI = 0.41, 0.55) and a nonsignificant combined effect size in the opposite direction for studies that used pictures (k = 5, d = −0.25, CI = −0.52, 0.01). Words produced significantly larger interference effect than did pictures (Q = 14.44, $p < .01$).

Do threat-related pictures yield larger bias effects than threat-related words within studies using the dot-probe paradigm? Threat-related bias in anxious participants was significant both with words (k = 20, d = 0.35, CI = 0.25, 0.46) and with pictures (k = 15, d = 0.38, CI = 0.26, 0.50), with no significant difference between the two. Of importance, nonanxious control participants displayed a significant bias away from threat in experiments using words (k = 17, d = −0.14, CI = −0.23, −0.05), and no bias with pictures.

Population-Related Moderators

Is Threat-Related Bias Stronger in Clinically Anxious Participants Than in Participants With High Self-Reported Anxiety?

Threat-related bias was significant in clinically diagnosed populations (k = 62, d = 0.45, CI = 0.38, 0.51) as well as in populations with high self-reported anxiety (k = 50, d = 0.46, CI = 0.38, 0.54). The combined effect sizes of the two populations did not differ.

Does the Magnitude of Threat-Related Bias Differ as a Function of Anxiety Disorder?

We compared the combined effect sizes of groups of studies that focused on specific anxiety disorders using threat stimuli that were congruent with the concerns of the specific disorder studied. Included were studies of GAD (k = 11), OCD (k = 6), panic disorder (k = 7), PTSD (k = 22), social phobia (k = 8), and simple phobia (k = 5). Tables 2 and 3 provide the detailed statistics of these comparisons. The results indicate that threat-related bias was significant for all the clinical disorders tested, with effect sizes ranging from 0.36 to 0.59. The combined effect sizes did not differ among the various disorders.

Does Comorbidity Between Anxiety and Mood Disorders Affect the Magnitude of Threat-Related Bias in Clinically Anxious Populations?

The combined effect sizes of bias were significant both for studies that excluded participants with comorbid mood disorders (k = 17, d = 0.43, CI = 0.33, 0.53) and for studies that did not

Table 2
Meta-Analytic Results of Within-Group Threat-Related Biases for Anxious Participants (k = 112 Outcomes) and Control Participants (k = 87 Outcomes)

	Within anxious						Within control						Anxious vs. control	
Moderator	k	N	d	85% CI	Q^a	p	k	N	d	85% CI	Q	p	Q^b	p
Total data set	112	2.263	0.45****	0.40, 0.49			87	1,768	−0.007	−0.06, 0.05			87.56	<.0001
Procedural moderators														
Stimulus exposure time														
Supraliminal	92	1,837	0.48****	0.42, 0.54	3.08	.08	72	1,427	0.009	−0.04, 0.06	1.41	.23	75.03	<.0001
Subliminal	20	426	0.32****	0.20, 0.44			15	641	−0.09	−0.20, 0.02			14.48	<.0001
Paradigm														
Stroop	70	1,467	0.49****	0.43, 0.56	2.39	.30	47	973	0.06	0.001, 0.12	5.92	<.05	40.25	<.0001
Dot probe	35	659	0.37****	0.28, 0.46			33	655	−0.09	−0.16, −0.01			38.96	<.0001
Posner	7	137	0.43**	0.23, 0.64			7	140	−0.11	−0.27, 0.05			7.32	<.01
Stroop design														
Blocked	31	645	0.69****	0.60, 0.78	14.78	<.0001	18	356	0.21**	0.10, 0.31	5.94	<.05	19.23	<.0001
Random	30	588	0.35****	0.26, 0.44			22	432	−0.03	−0.12, 0.06			21.94	<.0001
Stimulus type														
Words	88	1,798	0.46****	0.40, 0.52	0.14	.71	63	1,304	−0.006	−0.06, 0.05	0.02	.90	64.06	<.0001
Pictures	24	465	0.43****	0.32, 0.54			24	464	−0.02	−0.10, 0.07			21.77	<.0001
Paradigm × Exposure														
Dot probe—subliminal	5	93	0.65****	0.42, 0.88	4.04	.13	4	79	−0.28*	−0.47, −0.09	3.37	.19	20.13	<.0001
Dot probe—500 ms	18	339	0.31****	0.20, 0.43			19	375	−0.06	−0.15, 0.02			13.86	<.0001
Dot probe—≤1,000 ms	7	141	0.29*	0.11, 0.47			6	117	0.03	−0.13, 0.18			2.72	.10
Stroop—subliminal	15	333	0.23**	0.10, 0.35	11.57	<.001	11	626	−0.02	−0.15, 0.11	1.09	.30	4.95	<.05
Stroop—supraliminal	55	1,134	0.57****	0.50, 0.64			36	711	0.09	0.01, 0.17			32.43	<.0001
Stimulus Type × Exposure														
Supraliminal—words	72	1,433	0.51****	0.44, 0.57	1.73	.19	51	1,018	0.01	−0.05, 0.07	0.04	.85	57.04	<.0001
Supraliminal—pictures	20	404	0.38****	0.26, 0.50			21	409	−0.001	−0.09, 0.09			16.14	<.0001
Subliminal—words	16	365	0.24****	0.15, 0.34	5.25	<.05	12	286	−0.08	−0.21, 0.06	—	—	10.68	<.001
Subliminal—pictures	4	61	0.65****	0.42, 0.89			—	—	—	—			—	—
Stimulus Type × Paradigm														
Stroop—words	66	1,372	0.51****	0.44, 0.58	2.12	.15	44	901	0.06	−0.008, 0.13	—	—	36.71	<.0001
Stroop—pictures	4	95	0.24	−0.02, 0.50			—	—	—	—			—	—
Dot probe—words	20	388	0.35****	0.25, 0.46	0.05	.82	17	363	−0.14*	−0.23, −0.05	1.59	.21	35.90	<.0001
Dot probe—pictures	15	271	0.38****	0.26, 0.50			16	292	−0.03	−0.12, 0.07			10.99	<.0001
Population-related moderators														
Anxiety type														
Clinical anxiety	62	1,326	0.45****	0.38, 0.51	0.03	.86	40	872	0.05	−0.02, 0.11	2.59	.11	35.05	<.0001
High self-reported anxiety	50	937	0.46****	0.38, 0.54			47	896	−0.06	−0.12, 0.006			50.27	<.0001
Type of anxiety disorder														
GAD	11	202	0.56****	0.37, 0.66	4.57	.47								
OCD	6	76	0.45***	0.25, 0.65										
Panic disorder	7	170	0.50****	0.34, 0.66										
PTSD	22	502	0.36****	0.27, 0.46										
Social phobia	8	200	0.59****	0.43, 0.74										
Simple phobia	5	128	0.36**	0.43, 0.74										
Comorbid mood disorders														
Excluded	17	379	0.43****	0.33, 0.53	0.17	.68								
Included	24	433	0.47****	0.38, 0.56										
State vs. trait anxiety														
State	5	92	0.65****	0.42, 0.88	2.48	.12	5	103	−0.19	−0.33, 0.05	1.23	.27	30.45	<.0001
Trait	29	517	0.38****	0.28, 0.48			30	545	−0.07	−0.13, −0.008			30.82	<.0001

Table 2 (*continued*)

	Within anxious						Within control						Anxious vs. control	
Moderator	*k*	*N*	*d*	85% CI	Q^a	*p*	*k*	*N*	*d*	85% CI	*Q*	*p*	Q^b	*p*
Population-related moderators (*continued*)														
Age														
Adults	101	2,013	0.45^{****}	0.39, 0.50	0.24	.63	78	1,580	−0.009	−0.06, 0.04	0.00	.99	80.16	<.0001
Children	11	250	0.50^{****}	0.34, 0.66			9	188	0.008	−0.15, 0.13			7.35	<.01
Anxiety Type × Age														
Adults—clinical	54	1,141	0.45^{****}	0.38, 0.52	0.04	.84	34	751	0.05	−0.02, 0.13	2.35	.13	29.42	<.0001
Adults—nonclinical	47	872	0.43^{****}	0.36, 0.51			44	829	−0.06	−0.12, 0.01			48.84	<.0001
Children—clinical	8	185	0.40^{**}	0.24, 0.56	—	—	6	121	0.02	−0.16, 0.21	—	—	4.99	<.05
Children—nonclinical	—	—	—	—			—	—	—	—			—	—
Procedure × Population														
Exposure × Anxiety Type														
Clinical—supraliminal	48	1,013	0.51^{****}	0.44, 0.57	10.10	<.001	30	630	0.08	−0.007, 0.17	1.01	.32	32.09	<.0001
Clinical—subliminal	14	313	0.22^{**}	0.11, 0.33			10	242	−0.04	−0.19, 0.11			5.62	<.05
Nonclinical—supraliminal	44	824	0.45^{****}	0.35, 0.54	0.67	.41	42	797	−0.04	−0.10, 0.01	1.20	.27	38.79	<.0001
Nonclinical—subliminal	6	131	0.61^{***}	0.34, 0.87			5	99	−0.18	−0.35, −0.01			12.51	<.0001
Paradigm × Anxiety Type														
Clinical—Stroop	45	1,006	0.48^{****}	0.41, 0.55	2.20	.13	26	580	0.09	−0.001, 0.19	.65	.42	22.56	<.0001
Clinical—dot probe	16	302	0.34^{****}	0.22, 0.46			13	272	0.002	−0.13, 0.13			9.31	<.01
Nonclinical—Stroop	25	461	0.51^{****}	0.38, 0.64	0.71	.70	21	393	0.02	−0.06, 0.10	4.26	.12	16.44	<.0001
Nonclinical—dot probe	19	357	0.40^{****}	0.25, 0.55			20	383	-0.14^{**}	−0.22, −0.06			30.68	<.0001
Nonclinical—Posner	6	119	0.48^{**}	0.23, 0.74			6	120	−0.06	−0.20, 0.09			5.78	<.05
Stimulus Type × Anxiety Type														
Clinical—words	57	1,221	0.46^{****}	0.40, 0.52	2.60	.11	36	793	0.03	−0.05, 0.11	1.69	.19	39.95	<.0001
Clinical—pictures	5	105	0.22	0.02, 0.42			4	79	0.26	0.02, 0.50			.02	.88
Nonclinical—words	31	577	0.45^{****}	0.34, 0.63	0.09	.77	27	511	−0.05	−0.12, 0.02	0.05	.82	22.57	<.0001
Nonclinical—pictures	19	360	0.49^{****}	0.34, 0.57			20	385	−0.07	−0.15, 0.02			30.63	<.0001
Paradigm × Age														
Adults—Stroop	64	1,330	0.47^{****}	0.40, 0.53	1.20	.55	42	864	0.08	0.008, 0.14	7.09	<.05	33.00	<.0001
Adults—dot probe	30	546	0.38^{****}	0.29, 0.48			29	576	−0.10	−0.18, −0.02			39.96	<.0001
Adults—Posner	7	137	0.43^{***}	0.24, 0.63			7	140	−0.11	−0.27, 0.05			7.32	<.01
Children—Stroop	6	137	0.69^{***}	0.40, 0.99	1.53	.22	5	109	−0.06	−0.20, 0.07	0.28	.59	7.16	<.01
Children—dot probe	5	113	0.32	−0.009, 0.64			4	79	0.02	−0.16, 0.20			1.15	.28
Age × Exposure														
Supraliminal—adults	81	1,587	0.48^{****}	0.42, 0.54	0.05	.83	63	1,239	0.01	−0.04, 0.07	0.05	.83	67.77	<.0001
Supraliminal—children	11	250	0.50^{****}	0.34, 0.67			9	188	−0.01	−0.14, 0.12			7.35	<.01
Subliminal—adults	20	426	0.32^{****}	0.20, 0.44	—	—	15	641	−0.09	−0.20, 0.02	—	—	14.48	<.0001
Subliminal—children	—	—	—	—			—	—	—	—			—	—
Stimulus Type × Age														
Words—adult	79	1,605	0.43^{****}	0.37, 0.49	3.78	<.05	56	1,163	−0.002	−0.06, 0.06	0.05	.83	50.64	<.0001
Words—children	9	193	0.68^{****}	0.51, 0.85			7	141	−0.03	−0.19, 0.14			18.00	<.0001
Pictures—adults	17	408	0.51^{****}	0.39, 0.63	—	—	17	417	−0.035	−0.13, 0.06	—	—	26.25	<.0001
Pictures—children	—	—	—	—			—	—	—	—			—	—

Note. Dashes indicate $k < 4$ (subcategories with $k < 4$ studies were not tested).
[a] Q for comparison between subcategories of a moderator. [b] Q for comparison between anxious and nonanxious control.
$^{*} p < .05$. $^{**} p < .01$. $^{***} p < .001$. $^{****} p < .0001$.

Table 3
Meta-Analytic Results of Between-Groups Comparisons (k = 125 Outcomes)

Moderator	k	Anxious n	Control n	d	85% CI	Q^{a}	p
Total data set	125	2,963	2,906	0.41****	0.34, 0.48		
Procedural moderators							
Stimulus exposure time							
Supraliminal	98	2,337	2,295	0.42****	0.34, 0.50	0.20	.65
Subliminal	27	593	583	0.37****	0.22, 0.52		
Paradigm							
Stroop	77	1,988	1,936	0.45****	0.36, 0.54	2.71	.26
Dot probe	44	889	887	0.38****	0.26, 0.50		
Posner	4	86	83	0.009	−0.38, 0.40		
Stroop design							
Blocked	30	784	716	0.56****	0.42, 0.70	1.84	.18
Random	39	1,015	1,027	0.38****	0.27, 0.50		
Stimulus type							
Words	98	2,438	2,361	0.44****	0.36, 0.52	1.66	.20
Pictures	26	476	494	0.28**	0.13, 0.44		
Paradigm × Exposure							
Dot probe—subliminal	6	126	123	0.56*	0.17, 0.95	1.12	.57
Dot probe—500 ms	25	469	472	0.41***	0.22, 0.60		
Dot probe—≤1,000 ms	11	210	189	0.22	−0.08, 0.51		
Stroop—subliminal	21	467	460	0.32**	0.17, 0.48	1.83	.18
Stroop—supraliminal	56	1,521	1,476	0.50****	0.40, 0.59		
Stimulus Type × Exposure							
Supraliminal—words	77	1,929	1,868	0.44****	0.35, 0.52	0.84	.36
Supraliminal—pictures	20	392	404	0.32**	0.16, 0.49		
Subliminal—words	21	509	493	0.42***	0.24, 0.61	0.74	.39
Subliminal—pictures	6	84	90	0.19	−0.17, 0.54		
Stimulus Type × Paradigm							
Stroop—words	71	1,870	1,814	0.48****	0.41, 0.55	14.44	<.0001
Stroop—pictures	5	87	89	−0.25	−0.52, 0.01		
Dot probe—words	24	502	483	0.37**	0.20, 0.53	0.04	.85
Dot probe—pictures	20	396	386	0.40**	0.22, 0.58		
Population-related moderators							
Anxiety type							
Clinical anxiety	50	1,229	1,138	0.50****	0.38, 0.61	1.94	.16
High self-reported anxiety	75	1,716	1,750	0.36****	0.27, 0.45		
Type of anxiety disorder							
Generalized anxiety disorder	12	221	236	0.55****	0.37, 0.73		
Obsessive-compulsive disorder	—	71	57	—	—		
Panic disorder	8	188	174	0.52****	0.31, 0.73		
Post-traumatic stress disorder	11	278	216	0.46**	0.28, 0.64		
Social phobia	5	153	169	0.46**	0.22, 0.71		
Simple phobia	8	233	192	0.53****	0.33, 0.73		
State vs. trait anxiety							
Trait	36	640	648	0.36****	0.22, 0.51	0.02	.88
State	8	140	141	0.33	0.04, 0.62		
Comorbid mood disorders							
Excluded	14	319	332	0.45****	0.29, 0.60	0.89	.35
Included	17	368	340	0.58****	0.44, 0.73		
Age							
Adults	108	2,298	2,257	0.42****	0.34, 0.49	0.09	.77
Children	17	647	631	0.38**	0.19, 0.56		
Anxiety Type × Age							
Adults—clinical	42	1,039	1,002	0.49****	0.37, 0.61	1.13	.29
Adults—nonclinical	66	1,259	1,255	0.37****	0.27, 0.47		
Children—clinical	8	190	196	0.52***	0.30, 0.74	2.16	.14
Children—nonclinical	9	457	495	0.23	0.04, 0.41		
Procedure × Population							
Exposure × Anxiety Type							
Clinical—supraliminal	37	899	815	0.57****	0.48, 0.66	5.43	<.05
Clinical—subliminal	13	330	323	0.29**	0.14, 0.44		

Table 3 (*continued*)

Moderator	k	Anxious n	Control n	d	85% CI	Q^a	p
			Procedure × Population (*continued*)				
Exposure × Anxiety Type (*continued*)							
Nonclinical—supraliminal	61	1,453	1,490	0.34^{****}	0.24, 0.45	0.31	.58
Nonclinical—subliminal	14	293	260	0.44^{**}	0.22, 0.66		
Paradigm × Anxiety Type							
Clinical—Stroop	33	892	797	0.54^{****}	0.44, 0.64	1.54	.46
Clinical—dot probe	17	337	341	0.40^{****}	0.25, 0.54		
Nonclinical—Stroop	44	1,096	1,139	0.38^{****}	0.26, 0.51	0.18	.60
Nonclinical—dot probe	27	534	528	0.37^{***}	0.21, 0.53		
Nonclinical—Posner	4	86	83	0.009	−0.41, 0.43		
Stimulus Type × Anxiety Type							
Clinical—words	43	1,090	977	0.53^{****}	0.45, 0.61	6.57	<.01
Clinical—pictures	6	108	128	0.09	−0.15, 0.32		
Nonclinical—words	55	1,348	1,384	0.37^{****}	0.25, 0.48	0.02	.89
Nonclinical—pictures	20	368	366	0.34^{**}	0.16, 0.53		
Paradigm × Age							
Adults—Stroop	66	1,478	1,408	0.48^{****}	0.38, 0.57	3.40	.18
Adults—dot probe	38	734	766	0.36^{****}	0.23, 0.49		
Adults—Posner	4	86	83	0.009	−0.39, 0.41		
Children—Stroop	11	510	528	0.27^{*}	0.10, 0.44	1.39	.24
Children—dot probe	6	137	103	0.53^{**}	0.26, 0.79		
Age × Exposure							
Supraliminal—adults	81	1,705	1,674	0.43^{****}	0.35, 0.52	0.21	.64
Supraliminal—children	17	647	631	0.37^{**}	0.19, 0.55		
Subliminal—adults	27	593	583	0.37^{****}	0.22, 0.52	—	—
Subliminal—children	—	—	—	—	—		
Stimulus Type × Age							
Words—adult	83	1,848	1,777	0.44^{****}	0.36, 0.53	0.10	.76
Words—children	15	590	584	0.40^{**}	0.21, 0.59		
Pictures—adults	24	419	447	0.29^{*}	0.10, 0.49	—	—
Pictures—children	—	—	—	—	—		

Note. Dashes indicate $k < 4$ (subcategories with $k < 4$ studies were not tested).
[a] Q for comparison between subcategories of moderator.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. $^{****}p < .0001$.

exclude participants with comorbid mood disorders ($k = 24$, $d = 0.47$, CI = 0.38, 0.56). There was no difference between these two combined effect sizes, suggesting that co-occurrence of mood disorders with anxiety does not play a major role in the threat-related bias of anxious individuals.

Is There a Difference in the Threat-Related Bias When the High- and Low-Anxiety Groups Are Based on State Versus Trait Anxiety?

In these analyses, only studies that relied on Spielberger's state–trait anxiety scales (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) were included. For anxious participants, studies that relied on state anxiety for assigning participants to anxious versus nonanxious groups produced a somewhat larger combined within-group effect size ($k = 5$, $d = 0.65$, CI = 0.42, 0.88) than did studies that relied on trait anxiety ($k = 29$, $d = 0.38$, CI = 0.28, 0.48). However, the difference between these combined effect sizes was not significant.

The results of the between-groups analyses revealed a somewhat different picture. A significant difference between anxious and control participants was found in studies that relied on trait anxiety ($k = 36$, $d = 0.36$, CI = 0.22, 0.51), but not in studies that relied on state anxiety ($k = 8$, $d = 0.33$, $p = .10$, CI = 0.04, 0.62). Yet, the difference between the combined effect sizes was again not significant.

Do Children and Adults Show a Similar Threat-Related Bias?

Threat-related bias was significant in anxious adults ($k = 101$. $d = 0.45$, CI = 0.39, 0.50) and in anxious children ($k = 11$, $d = 0.50$, CI = 0.34, 0.66) and did not differ between the two groups.

Clinical Diagnosis Versus High Self-Reported Anxiety by Age

The bias in anxious adults was significant both for clinical populations ($k = 54$, $d = 0.45$, CI = 0.38, 0.52) and for populations with high self-reported anxiety ($k = 47$, $d = 0.43$, CI = 0.36, 0.51) and did not differ between the two population types. There were not enough samples to conduct within-group meta-analyses with children ($k = 3$ for anxious children and $k = 3$ for nonanxious control children in studies relying on self-reported anxiety).

The between-groups data revealed a significant difference between anxious and control adults in both the clinically diagnosed samples ($k = 42$, $d = 0.49$, CI $= 0.37, 0.61$) and the samples relying on self-reported anxiety ($k = 66$, $d = 0.37$, CI $= 0.27, 0.47$). In children, a significant difference between the anxious and control groups was found in the clinically diagnosed samples ($k = 8$, $d = 0.52$, CI $= 0.30, 0.74$), but not in the samples relying on self-reported anxiety ($k = 9$, $d = 0.23$, $p = .07$, CI $= 0.04, 0.41$). However, the between-groups effect sizes did not differ between the two types of child population.

Interactions Between Procedural and Population-Related Moderators

Does Stimulus Exposure Time Differentially Modulate the Bias in Clinically Diagnosed Participants Versus in Participants With High Self-Reported Anxiety?

In clinically anxious populations, threat-related bias was significant both with supraliminal exposures ($k = 48$, $d = 0.51$, CI $=$ $0.44, 0.57$) and with subliminal exposures ($k = 14$, $d = 0.22$, CI $=$ $0.11, 0.33$). The combined effect size was larger for supraliminal exposures than for subliminal exposures ($Q = 10.10$, $p < .01$). Consistent with this finding, the between-groups analyses showed significant differences between clinically anxious and control individuals both with supraliminal exposures ($k = 37$, $d = 0.57$, CI $= 0.48, 0.66$) and with subliminal exposures ($k = 13$, $d = 0.29$, CI $= 0.14, 0.44$) and a larger effect size for the supraliminal than for the subliminal exposures ($Q = 5.43$, $p < .05$).

In studies relying on self-reported anxiety, threat-related bias was also significant both for supraliminal exposures ($k = 44$, $d =$ 0.45, CI $= 0.35, 0.54$) and for subliminal exposures ($k = 6$, $d =$ 0.61, CI $= 0.34, 0.87$), but the difference between the two exposures was not significant.

A direct comparison of the combined effect sizes for clinically anxious individuals and individuals with high self-reported anxiety revealed that the effect sizes of the two groups did not differ with supraliminal exposures, but that with subliminal stimulus exposures the combined effect size was significantly smaller for clinically anxious participants than for participants with high self-reported anxiety ($Q = 5.49$, $p < .05$).

Does Experimental Paradigm Differentially Modulate Threat-Related Bias in Clinically Diagnosed Participants Versus in Participants With High Self-Reported Anxiety?

With clinically diagnosed participants, the bias was significant and did not differ between emotional Stroop studies ($k = 45$, $d =$ 0.48, CI $= 0.41, 0.55$) and dot-probe studies ($k = 16$, $d = 0.34$, CI $= 0.22, 0.46$). There was only one study using the emotional spatial cuing paradigm with clinically diagnosed participants (Amir, Elias, Klumpp, & Przeworski, 2003), which precluded further analysis with this paradigm. In control participants for clinical studies, there was no threat-related bias.

In participants with high self-reported anxiety, the combined effect sizes of the bias were significant and did not differ for emotional Stroop studies ($k = 25$, $d = 0.51$, CI $= 0.38, 0.64$), dot-probe studies ($k = 19$, $d = 0.40$, CI $= 0.25, 0.55$), or emotional spatial cuing studies ($k = 6$, $d = 0.48$, CI $= 0.23, 0.74$). In control participants, there was no significant threat-related bias in either emotional Stroop studies or emotional spatial cuing studies, whereas a significant bias away from threat was found in dot-probe studies ($k = 20$, $d = -0.14$, CI $= -0.22, -0.06$). However, none of the between-paradigms differences were significant.

Do Words and Pictures Differentially Modulate Threat-Related Bias in Clinical Participants Versus in Participants With High Self-Reported Anxiety?

In clinically diagnosed participants, the bias was significant with words ($k = 57$, $d = 0.46$, CI $= 0.40, 0.52$), but not with pictures. In addition, the difference between the combined effect sizes from the within-group analyses in clinically anxious versus control participants was significant for studies using words ($Q = 39.95$, $p < .01$), but not for studies using pictures. In line with these findings, the between-groups effect was also significant with words ($k = 43$, $d = 0.53$, CI $= 0.45, 0.61$) and nonsignificant with pictures, with a significant difference between the two effects ($Q = 6.57$, $p < .01$).

In studies relying on self-reported anxiety, the threat-related bias was significant both with words ($k = 31$, $d = 0.45$, CI $= 0.34, 0.63$) and with pictures ($k = 19$, $d = 0.49$, CI $= 0.34, 0.57$), with no difference between the two effects.

Does the Type of Experimental Paradigm Differentially Modulate the Bias in Children Versus in Adults?

The pattern of results regarding the effects of experimental paradigm in adults was similar to that of the full data set. Threat-related bias in anxious adults was significant in emotional Stroop ($k = 64$, $d = 0.47$, CI $= 0.40, 0.53$), dot-probe ($k = 30$, $d = 0.38$, CI $= 0.29, 0.48$), and emotional spatial cuing studies ($k = 7$, $d =$ 0.43, CI $= 0.24, 0.63$), with no difference between the paradigms. In control adults, there was no threat-related bias for any of the experimental paradigms. However, control participants in dot-probe and emotional spatial cuing studies showed a nonsignificant bias away from threat, whereas control participants in emotional Stroop studies showed a nonsignificant slowing with threat relative to neutral stimuli. This resulted in a significant difference among the combined effect sizes of the three paradigms ($Q = 5.91$, $p < .05$).

A different pattern of results emerged for children. The threat-related bias was significant in emotional Stroop ($k = 6$, $d = 0.69$, CI $= 0.40, 0.99$), but not in dot-probe studies ($k = 5$, $d = 0.32$, CI $= -0.009, 0.64$). The within-group combined effect size was significantly larger in anxious than in control participants in emotional Stroop studies ($Q = 7.16$, $p < .01$), but there was no difference between the two child populations in dot-probe studies. No emotional spatial cuing studies were conducted with children. Unlike the results of the within-group comparisons, the between-groups data showed a significant difference between anxious and control children both in emotional Stroop ($k = 11$, $d = 0.27$, CI $=$ $0.10, 0.44$) and in dot-probe studies ($k = 6$, $d = 0.53$, CI $= 0.26, 0.79$).

Do Stimulus Exposure Time and Stimulus Type Differentially Modulate the Bias in Children and Adults?

There were no studies of children using subliminal exposures. For supraliminal exposures, the combined effect sizes of anxious adults (k = 81, d = 0.48, CI = 0.42, 0.54), and anxious children (k = 11, d = 0.50, CI = 0.34, 0.67) were significant and did not differ from each other.

Only two studies with children used picture stimuli, thus precluding a comparison between adults and children on this variable. For word stimuli, the bias was significant both for anxious adults (k = 79, d = 0.43, CI = 0.37, 0.49) and for anxious children (k = 9, d = 0.68, CI = 0.51, 0.85), with children showing a larger effect size than adults (Q = 3.78, $p < .05$).

Discussion

The main conclusion of this set of meta-analytic studies is that the threat-related bias is a robust phenomenon in anxious individuals and does not exist in nonanxious individuals. Although the threat-related bias in anxious individuals holds under a variety of experimental conditions, and in different types of anxious populations, this consistent phenomenon is of low-to-medium effect size. The meta-analytic finding for the anxious participants cannot be reduced to insignificance in the next 11,339 studies, even if those studies yielded only null results. This number is 20 times as large as Rosenthal's (1991) fail-safe number, $5k + 10 = 570$ (k = number of studies included), such that the file-drawer problem is not of concern here. In fact, this large fail-safe number points to the diminishing returns to be expected from further studies that only focus on establishing the presence of a threat-related bias in anxious groups. New directions for further research in this exciting area are needed based on the premise of a moderate attentional bias in anxious participants.

No Threat-Related Bias in Nonanxious Individuals

The absence of a threat-related bias in nonanxious participants suggests that threat-related material presented in controlled experimental environments does not summon the attention of nonanxious individuals more than does neutral material. This finding appears to be inconsistent with previous literature suggesting that all humans are prewired to automatically orient toward potential threat in the environment (e.g., LeDoux, 1995; Ohman, 1993) or with visual search studies with normative samples showing that a face displaying a threatening emotion is detected faster than a face displaying either a neutral or a happy expression (e.g., Eastwood, Smilek, & Merikle, 2001; Fox, Lester, Russo, Bowles, & Dutton, 2000; Hansen & Hansen, 1988).

Two possible explanations for this discrepancy might be suggested but should be rejected on the basis of the present meta-analysis. First, many of the studies on nonclinical populations reported in the present meta-analysis used low-anxious participants (e.g., bottom quartile of the distribution of a normative population on an anxiety index) as opposed to groups from the general population with an average anxiety level that were tested in studies investigating attention to threat with no reference to anxiety. Thus, one could argue that the control groups tested in the present analyses represent a group of people with unusually low levels of anxiety. This explanation is unlikely, however, because null bias effects were found also for control participants in studies of clinical populations, where such selection bias did not prevail. Second, it could be argued that the bias toward threat stimuli in the general population may be specific to naturalistic or biologically valid stimuli and not hold for word stimuli. However, the present meta-analysis shows that naturalistic stimuli (threat-related pictures) produced null effects in the control group just as did threat-related word stimuli.

It is noteworthy that a significant threat-related bias in nonanxious participants did emerge in one experimental condition, namely, in the blocked-design emotional Stroop. It may be the case that a threat-related bias may be detected in nonanxious participants with experimental designs that involve cumulative exposure to threat-related stimuli and thereby produce stronger perceived threat. Consistent with this interpretation, it has been suggested that whereas anxious individuals show an attentional bias even with mildly threatening stimuli, nonanxious individuals show a bias only with high levels of threat (e.g., Mogg & Bradley, 1999b; Wilson & MacLeod, 2003). Unfortunately, this hypothesis could not be tested in the present meta-analysis because a comparison of stimuli's threat levels across studies was impossible.

In addition, the results partially support the suggestion that under mild threat conditions, nonanxious individuals in fact show avoidance of threat-related stimuli and shift attention away from them (e.g., MacLeod et al., 1986; Williams et al., 1988). A significant bias away from threat was observed in control individuals under specific conditions in dot-probe studies (i.e., with subliminal exposure times, with word stimuli, and in nonclinical populations). However, these findings should be interpreted with caution, because the effect sizes are small and not consistent across studies.

Stimulus Awareness Modulates the Bias in Opposite Directions in Emotional Stroop and Dot-Probe Studies

The meta-analysis indicates that subliminally perceived threat summons anxious individuals' attention, which entails that the attentional bias in anxiety is not contingent on conscious perception of threat. However, the combined effect size of the bias was smaller with subliminal exposures than with supraliminal exposures, which indicates that part of the threat-related bias in anxious individuals does result from processes that require conscious perception.

Furthermore, preconscious and conscious processes were found to be differentially tapped by the emotional Stroop and the dot-probe paradigms. In emotional Stroop studies, although combined effect sizes in anxious participants were significant both with subliminal and with supraliminal exposures, the latter was significantly larger. This finding suggests that conscious processes play a prominent role in this paradigm. The reverse pattern was observed in dot-probe studies. Subliminal exposures yielded a combined effect size in anxious individuals that was almost twice as large as that yielded by supraliminal exposures, suggesting that conscious processes contribute relatively little to the threat-related attentional bias reported in dot-probe studies. This pattern of results is consistent with the claim that the bias observed using the emotional Stroop reflects relatively late, controlled processes, whereas the bias revealed using the dot-probe paradigm reflects earlier attentional processes (see MacLeod et al., 1986).

Naturalistic Threat Stimuli Produce Larger Bias Than Word Stimuli Only When Presented Subliminally

Overall, the findings do not support the claim that naturalistic threat stimuli (e.g., pictures of angry or fearful faces, spiders, etc.)

are more potent than word stimuli for the assessment of a threat-related bias in anxious individuals. Indeed, the combined effect sizes of studies using picture stimuli versus words did not differ. With subliminal exposures, however, naturalistic stimuli did show the expected superiority, as the combined effect size was almost 3 times as large with naturalistic stimuli as with word stimuli. This result may reflect the fact that relative to sensory processing, semantic processing requires longer exposures. Thus, when enough time is provided for processing of threat-related stimuli, both words and naturalistic stimuli induce similar bias effects, but when extremely fast, automatic processing is required, biologically salient stimuli are more potent in eliciting a threat-related bias. This interpretation is consistent with descriptions of a fast and direct neural relay of sensory information to the mammalian amygdala, which is dedicated to the processing of potentially dangerous events in the natural environment (LeDoux, 1995; LeDoux, Cicchetti, Xagoraris, & Romanski, 1990).

However, two additional observations call for cautious consideration of this conclusion. First, despite the inherent problems associated with the interpretation of between-subjects comparisons (as explained in the introduction), these revealed a significant combined effect for subliminally presented words and a nonsignificant combined effect for subliminally presented pictures. Second, further exploration of the data from subliminal exposures in within-subject analyses suggests a possible confound between stimulus type and paradigm. There were more studies using the dot-probe paradigm than studies using the emotional Stroop paradigm with naturalistic stimuli (3 vs. 1), whereas there were more studies using the Stroop paradigm than studies using the dot-probe paradigm with words (14 vs. 2). Because the dot-probe paradigm tends to produce larger subliminal effects than does the Stroop paradigm, the paradigm used rather than the type of stimulus might account for the observed advantage of naturalistic stimuli over word stimuli with subliminal exposures. Because of the small number of studies currently available in each relevant cell, conclusions that are more definitive must await further investigation.

The Threat-Related Bias Is Similar in Clinically Anxious and Nonclinical High-Anxious Participants

The meta-analysis did not support the hypothesis that clinically anxious individuals present a more robust bias than do individuals with high levels of self-reported anxiety. Indeed, we found equivalent combined effect sizes of threat-related bias in the two populations. These findings suggest that an official clinical cutoff is of little significance with regard to biased attentional processes in anxious individuals, and that milder forms of anxiety are sufficient for triggering the full potential of the bias. Thus, it appears that the existence of a threat-related bias may not suffice to determine whether a highly anxious individual will develop an anxiety disorder. To determine whether the bias is nonetheless an etiological factor in clinical anxiety, it will be useful to obtain individual data in addition to group means in order to estimate what proportion of clinically anxious participants does not present the bias at all.

In addition, there is some indication in the data that the threat-related bias in clinical anxiety might be dependent on conscious processing of the threat-related stimuli. Indeed, clinically anxious participants showed larger combined effects size with supraliminal exposures than with subliminal exposures, whereas nonclinically anxious participants showed equivalent combined effect sizes for the two exposure conditions. This finding may have important practical implications for future interventions aiming at a systematic reduction of the bias in clinically anxious patients, suggesting that focusing on the conscious aspects of the bias may be most beneficial. However, this conclusion should be approached with caution because scrutiny of the data showed that with clinical samples the Stroop paradigm, which yields larger bias effects with supraliminal stimuli, was more frequently used than the dot-probe paradigm, which yields larger bias effects with subliminal stimuli. With nonclinical samples, the imbalance in the relative number of studies in each paradigm was much smaller.

The Magnitude of the Threat-Related Bias Is Similar in All Anxiety Disorders

Considering the diverse phenotypes of the different anxiety disorders, the finding of a similar-size bias in all the anxiety disorders studied is striking. This finding might indicate that the bias is related to a core anxiety component that is common to all anxiety disorders as well as to nonclinical anxiety. Although this idea cannot accommodate the often reported finding that no attentional bias is found in individuals with depression despite high comorbidity with clinical anxiety and high levels of reported anxiety (for a review, see Mogg & Bradley, 2005), it is noteworthy that the present meta-analysis showed that whether or not participants with depression were included in the anxious group did not modulate the attentional bias effect.

Children and Adults Show a Similar Pattern of Threat-Related Bias

The meta-analysis shows that the combined effect sizes in anxious children and in anxious adults were both significant and did not differ from each other. The results further show that nonanxious children and nonanxious adults show no threat-related bias. However, because there were not enough studies with children to allow a more sensitive breakdown of the data by age group and because many of the studies with children used a wide age range, a more detailed description of the developmental course of attentional bias in children must await further research.

Cognitive Mechanisms Underlying Threat-Related Bias in Anxiety

As reviewed in the introduction, several theoretical views of the mechanisms underlying threat-related bias in anxiety have been proposed. Although a common aspect of these views is an emphasis on the role of preattentive and attention-allocation processes in trait anxiety, there is no consensus as to the exact mechanisms underlying these biases.

Williams at al. (1988, 1997) have proposed that two cognitive mechanisms are responsible for the threat-related bias in anxious individuals: an affective decision mechanism (ADM) and a resource allocation mechanism (RAM; or task demand unit in the 1997 model). The function of the ADM is to assess the threat value of stimuli. The RAM receives input from the ADM and determines resource allocation. According to Williams et al., individual differences in the RAM underlie individual differences in trait anxiety, with high-trait-anxious individuals showing a permanent tendency to orient toward threat and low-trait-anxious individuals tending to shift attention away from threat.

Mogg and Bradley (1998) proposed a cognitive-motivational model in which individual differences in trait anxiety concern the reactivity of a valence evaluation system (VES) that is similar to Williams et al.'s (1988, 1997) ADM. According to Mogg and Bradley (1998), the VES is more sensitive in high-trait-anxious individuals, that is, stimuli that nonanxious individuals tag as nonthreatening are tagged as threatening by anxious individuals. Output from the VES feeds into a goal engagement system that determines the allocation of resources for cognitive processing and action. In this model, if a high threat value is assigned to a stimulus, interruption of ongoing activity is automatically determined in both high- and low-anxious individuals. Other researchers (e.g., Wells & Matthews, 1994) have advanced a completely different view, focusing on voluntary, strategic processes in mediating biases in anxiety.

Although the findings from the present meta-analysis do not offer clear-cut support for one model over the other, they undoubtedly challenge some of the outcomes predicted by each of them. First, our findings suggest that Williams et al.'s (1988, 1997) claim that low-trait-anxious individuals show bias away from threat is at best a very weak phenomenon. Second, the meta-analytic data show that individual differences in anxiety are most probably driven both by preattentive threat detection biases, as reflected in the unequivocal evidence for a bias with stimuli outside awareness, and by later resource allocation mechanisms and top-down processes, as reflected in the larger effect size for consciously perceived relative to subliminally exposed threat-related stimuli. The distinction between separate contributions of unconscious and conscious processes to threat processing in anxiety is further validated by the fact that stimulus awareness modulates the bias in opposite directions in emotional Stroop versus dot-probe studies. Thus, although the present findings provide some support for Mogg and Bradley's (1998), Williams et al.'s (1988, 1997), and Wells and Matthews's (1994) models, they also suggest that strong claims that bias in only one stage of processing accounts for the attentional bias in anxiety should be toned down. The meta-analytic results imply that the valence-based bias in anxiety is a function of several cognitive processes, including preattentive, attentional, and postattentive processes.

Because existing models cannot account for the outline of the findings that emerged from the present meta-analysis, a new theoretical framework is in order. We offer a tentative integrative model (see Figure 1) that incorporates several aspects of previous models and is consistent with the findings of the present meta-analysis. Instead of assigning the bias to a malfunction of only one cognitive process, we propose that anxious individuals may display abnormal processing patterns at each of four different stages or in different combinations of these. According to this model, a preattentive threat evaluation system (PTES) preattentively evaluates stimuli in the environment. A stimulus that is tagged with a high threat value feeds forward into a resource allocation system (RAS) and triggers a physiological alert state, interruption of ongoing activity, allocation of processing resources to the stimulus, and a conscious anxious state. These outcomes lead to a set of strategic processes carried out by a guided threat evaluation system (GTES). At this stage, assessment of the context of the threat stimulus, comparison of the present threat with prior learning and memory, and assessment of the availability of coping resources take place. If the outcome of this guided threat evaluation results in a low conscious threat evaluation, a feedback process is triggered that overrides the input emanating from the PTES and relaxes the alert state imposed by the RAS. If, in contrast, the result of this guided evaluation corroborates the threat alert invoked by the PTES, a high state of anxiety is likely to proceed.

Construed in this manner, high-trait anxiety or different anxiety disorders may stem from (a) a tendency to automatically evaluate benign or slightly threatening stimuli as high threat; (b) a bias in the RAS, that is, a tendency to allocate resources even to stimuli evaluated as only mildly threatening; (c) a tendency to consciously evaluate alert signals as highly threatening even when context, prior learning, and available coping resources may indicate the contrary; or (d) deficiencies in the overriding mechanism, in which

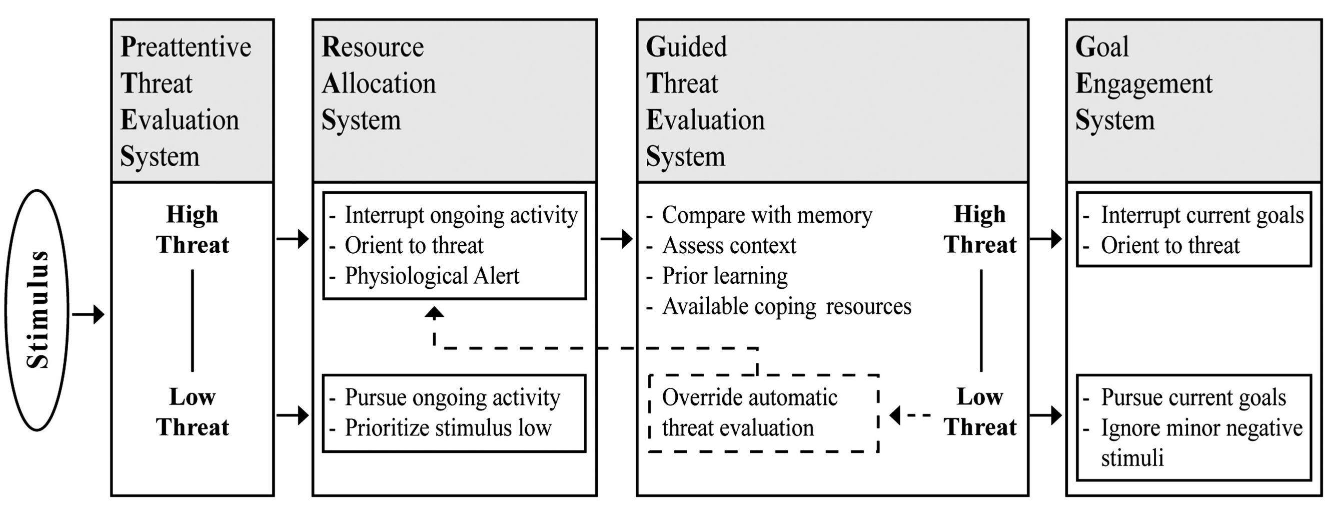

Figure 1. A model of the cognitive mechanisms underlying threat processing.

case even conscious understanding of the irrational aspects of the threat evaluation cannot terminate the anxious state.

Taking into account the striking finding of a similar bias across anxious populations, one may speculate that phenotypic differences between different anxious populations may be determined by the specific pattern of biases and malfunctions at different stages of the model. For instance, specific phobia is characterized by marked and persistent fear that is cued by the presence or anticipation of a specific object or situation. Exposure to the phobic stimulus almost invariably provokes an immediate anxiety response, which in our model may be attributed to a specific bias in the PTES, followed by an alert response of the RAS. An additional diagnostic feature of specific phobia is that the person recognizes that his or her fear is excessive and unreasonable, which, according to our model, may indicate that the GTES is functioning properly in specific phobia but that the overriding mechanism that is expected to relax the alert state imposed by the RAS may be dysfunctional.

Other anxiety disorders may involve dysfunctions in other stages of threat processing. For example, Foa and colleagues (Foa, Feske, Murdock, Kozak, & McCarthy, 1991; Foa, Steketee, & Rothbaum 1989) have proposed that patients with PTSD selectively attend to trauma-related stimuli because this material is readily activated in fear templates stored in memory as a consequence of the trauma. They have further proposed that when trauma-related structures are activated in patients with PTSD, these might interfere with other cognitive mechanisms that are required for the integration and assessment of incoming information. Thus, in addition to the high threat value being assigned to trauma-related stimuli in the PTES, and the vigorous alarm reaction enforced by the RAS, the GTES of individuals with PTSD may fail to integrate contextual, coping resources, and other relevant information, leading to the often reported symptom of dissociated reliving of the trauma.

This tentative multistage model offers an integrative conceptual framework for thinking about anxiety conditions. Although this model appears to accommodate many of the central findings in the field as well as various clinical observations, it awaits validation by direct experimental testing in future research.

Future Directions

With over 150 studies that have established the existence and typical magnitude of the threat-related bias in anxious individuals from different populations and with a variety of experimental conditions, it appears as if little will be gained from additional studies of threat-related bias unless these are strongly driven by theory. What then, should be the future directions for research in this field? We suggest a number of topics that, in our view, particularly deserve further investigation.

First, there is a need for more refined investigation of the different stages of information processing in which anxious and nonanxious people differ. This calls for new experimental setups (the emotional spatial cuing task recently introduced to the field is a good example), for the use of other outcome measures in addition to manual reaction time and accuracy (e.g., response variability), and for reliance on technologies that allow one to go beyond observed behavior in order to index the timing of specific cognitive processes (e.g., eye tracking, event-related potentials [ERPs]).

Second, although the notion that threat-related bias may contribute causally to the development and maintenance of anxiety largely underlies the impetus for research in the field (e.g., Kaspi, McNally, & Amir, 1995; MacLeod et al., 1986; Mogg, Bradley, et al., 1993), empirical support for such a causal link is scarce. Research efforts toward the establishment of this causal link are of primary importance. MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) took a first step in this direction by experimentally inducing differential attentional responses to emotional stimuli in nonanxious participants using a modified dot-probe task, and then examining the impact of the attentional manipulation on subsequent emotional vulnerability. The results supported the hypothesis that the induction of attentional bias modified emotional vulnerability, as revealed by participants' subsequent emotional reactions in a standardized stress task. However, whether the processes tapped in this study are similar to those leading to clinical anxiety, and whether emotional vulnerability may be adequately equated with anxiety, remains open to alternative interpretations.

A related issue concerns whether threat-related bias in anxious individuals might be an epiphenomenon of increased anxiety. Only a few studies have addressed this issue, and they have provided support for this hypothesis by showing that successful treatment of anxious patients led to a reduction or even the abolishment of the threat-related bias initially observed in these patients (e.g., Lundh & Oest, 2001; Mattia, Heimberg, & Hope, 1993; Mathews, Mogg, Kentish, & Eysenck, 1995). Clearly, more research is needed on this critical issue.

Third, the present review reveals a relative paucity in studies of threat-related bias in anxious and nonanxious children, with some areas, such as subliminal exposure times, not covered at all. Particularly missing are longitudinal studies tracing the development and the associations over time between threat-related bias and anxiety. This lack of longitudinal research is surprising, given that understanding childhood pathways to anxiety can provide a unique perspective from which to appreciate the initial structure and function of anxiety-related information processing in anxiety disorders. In addition, in future cross-sectional studies, it may be extremely useful to narrow the age range of participants, as children's performance on specific attention tasks varies considerably with age. For instance, it has been carefully documented that children 3.5 to 4.5 years of age find the day–night Stroop-like task extremely difficult (Gerstadt, Hong, & Diamond, 1994). Diamond, Kirkham, and Amso (2002) further demonstrated that whereas 4-year-olds perform at a chance rate (53% correct) on this task, 4.5-year-olds perform at an almost 80% correct rate, and for 6- to 7-year-olds, the task becomes trivially easy. These findings indicate that around 4 years of age, there exists a sensitive period of development in attention control functions tapped by this particular task. Future studies of attentional bias in anxious children would benefit immensely from well-documented norms on the relevant cognitive tasks.

Finally, it seems that the time is ripe for research into the neural substrates of the threat-related bias in anxious individuals. One example, albeit not using an attention paradigm, is a study by Straube, Kolassa, Glauer, Mentzel, and Miltner (2004). They used event-related functional magnetic resonance imaging to assess brain activation in response to photographs and schematic pictures depicting angry or neutral facial expressions in participants with social phobia and in healthy control participants. Straube et al. found that differences between participants with social phobia and nonanxious controls in brain responses to socially threatening faces were most pronounced when facial expression was task irrelevant, and that the insula played a unique role in the intensive processing of angry facial expressions by the group with social phobia. An additional study by Bar-Haim, Lamy, and Glickman (2005) used event-related brain potentials to study the deployment of attention to face stimuli with different emotion expressions in high-anxious and low-anxious participants. The ERP data indicated that threat-related faces elicited faster latencies and greater amplitudes of early ERP components in high-anxious individuals than in low-anxious individuals. More studies using different attention paradigms and different measures of brain activity are needed in order to further elucidate the neural correlates of threat-related biases in anxiety.

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