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Phenomenological Characteristics of Attentional Biases Towards Threat: A Critical Review

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Abstract

Although research has consistently revealed the presence of a general attentional bias towards threat, empirical and theoretical ambiguity exists in determining whether attentional biases are comprised of facilitated attention to threat, difficulty in disengagement from threat, or both, as well as whether attentional biases reflect automatic or strategic processes. This paper reviews empirical investigations across 4 common assessment tasks: the Stroop (masked and unmasked), dot probe, visual search, and the Posner tasks. Although the review finds inconsistencies both within and between assessment tasks, the evidence suggests that attentional biases towards threat are comprised of each of the phenomenological characteristics addressed in this paper. Contemporary theoretical models of attentional biases in anxiety are summarized and critically reviewed in light of the current evidence. Suggestions for future research are addressed, including a need to investigate the psychometric properties of the assessment tasks, to utilize consistent theoretically driven operationalizations of attentional biases, and to provide a temporal description of the characteristics of attentional biases towards threat.

Keywords

Information processing biases; attentional biases; anxiety; Stroop; dot probe

1. Introduction

Anxiety is associated with a bias in attention toward threatening stimuli (e.g., Mathews & MacLeod, 2005; Mogg & Bradley, 1998; Williams, Mathews, & MacLeod, 1996). Experimental psychopathology research has utilized several different methods to assess attention and each of these tasks provides support for the existence of attentional biases towards threatening stimuli. Recently, Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, and van IJzendoorn (2007) reported a meta-analysis of attentional bias towards threat from 172 studies and across different stimuli, populations, and experimental tasks (i.e., the Stroop, dot probe, and Posner tasks). The results revealed the robustness of attentional biases, with an effect size of $d = .45$. Given that attentional biases are established as a robust phenomenon, Bar-Haim and colleagues recommended that future research focus on more theoretically-oriented aspects of attentional bias. One relevant line of inquiry pertains to the sub-components that comprise attentional bias. That is, do attentional biases reflect facilitated attention towards threatening stimuli, a difficulty in disengagement from threatening stimuli, or both (e.g., Amir, Elias, Klumpp, & Przeworski, 2003; Fox, 2004; Fox, Russo, Bowles, & Dutton, 2001)? Second, do attentional biases reflect automatic or

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strategic processes (e.g., Beck & Clark, 1997; McNally, 1995; Mogg, Bradley, Williams, & Mathews, 1993; Thorpe & Salkovskis, 1997)?

Past reviews of the extensive attentional bias literature have focused on moderators of the general attentional bias effect (Bar-Haim et al., 2007; Mogg & Bradley, 2005; 2004; 1998; Williams et al., 1996). For example, Mogg and Bradley (2005) reviewed attentional biases towards threat as a function of generalized anxiety disorder (GAD) versus depression, paying particular attention to stimulus presentation duration. The present line of inquiry adds to the theory of attentional bias by elucidating the components that comprise the attentional bias effect. This discussion is essential in that potential moderators (e.g., stimulus presentation duration, anxious population, stimulus type) may differentially affect the different phenomenological features of attentional biases (e.g., facilitated attention may only be observed at particular stimulus presentation durations; Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006). Thus, the elucidation of phenomenological features of attentional biases towards threat can inform researchers investigating factors that modulate the attentional bias effect. Currently, the only extant review of the phenomenological features of anxiety-related attentional biases has been provided by Fox (2004), who similarly examined evidence of whether attentional biases reflect facilitated attention versus difficulty in disengagement. The present review goes beyond Fox (2004) by noting key methodological operations that define the different phenomenological features across the different tasks, integrating findings across tasks to provide convergent evidence of the attentional bias features, critically evaluating extant information processing theories of anxiety in light of the review, and providing key suggestions for future research.

We begin by first summarizing existing research explaining the relation between anxiety and attentional biases in order to provide a theoretical framework for the current review. Second, we describe the methodological and conceptual aspects of common attentional bias assessment tasks that will be used in the review. Third, we review evidence from each task in regards to the attentional bias features and provide a summary that integrates findings across tasks as they relate to the attentional bias features. We begin first with the question of facilitated attention and difficulty in disengagement and then explore the questions of automatic and strategic stages of processing in attentional bias. Fourth, we examine extant information processing theories of anxiety in light of the current review. Fifth, we provide key suggestions for future research that will help clarify the phenomenological features of attentional biases towards threat.

Studies included in the current review were gathered from searches of the psycINFO database conducted through July 2007 using combinations of the following terms: visual search, stroop, dot probe, posner, exogenous, anxiety, fear, threat, attention, facilitated, facilitation, disengage, and disengagement. Additional studies were gathered from the references of included studies. Inclusion in the current review was determined if the study utilized one of the four assessment tasks (e.g., Stroop, Posner paradigm, dot probe, or visual search) to test attentional biases to a threatening stimulus with an anxious (either clinical or subclinical) adult population.

It is important to note two aspects that will not be addressed in this review. The first concerns studies that find that priming anxiety eliminates the attentional bias (e.g., Amir et al., 1996; Constans, Vasterling, McCloskey, & Brailey, 2004), which has proved difficult to interpret (see Mogg and Bradley, 2004; 1998). While this suppression phenomenon is a worthy topic of empirical discussion, the present review focuses solely on the phenomenological characteristics of attentional biases towards threat. Second, the review will focus on attentional biases towards threat as it relates to anxiety, and not towards other

types of stimuli that are also associated with attentional biases (e.g., cues of pain; addiction, depression, or eating-related cues).

2. The relation between anxiety and attentional biases towards threat

Common theories of attention suggest that attentional allocation to a stimulus is partially dependent on how pertinent, or relevant, the stimulus is to a particular organism (Bundensen, Habekost, & Kyllingsbaek, 2005; Norman, 1968). This model of normative (i.e., non-pathological) attention corresponds with recent findings regarding the development of attentional biases to threatening stimuli among anxious populations. Several recent studies demonstrate that previously non-valenced stimuli come to elicit attentional biases after the stimuli have been paired with aversive stimuli during classical conditioning (Koster, Crombez, Van Damme, & De Houwer, 2005, 2004; Smith, Most, Newsome, & Zald, 2006). These studies suggest that attentional biases are consequences of the ability of a stimulus to elicit fear in the same manner that enhanced skin conductance is a consequence of the ability of a stimulus to elicit fear. Further evidence of attentional biases as consequences of anxiety or fear come from studies demonstrating positive correlations between amygdala activation, a neural structure strongly implicated in the fear response (Öhman & Wiens, 2005; Phelps & LeDoux, 2005), and attentional biases (Anderson & Phelps, 2001; Monk et al. 2004). Öhman (2005) argues that activation of neural fear circuits recruits attention onto the eliciting stimulus, thus facilitating the organism's defensive response to the eliciting stimulus. From this perspective, attentional biases are viewed as factors that maintain, but do not cause, anxiety (Mogg & Bradley, 1998).

Alternatively, some research has suggested that attentional biases cause anxiety (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Mathews & MacLeod, 2002). For example, MacLeod and colleagues (2002) trained individuals to either attend towards or away from threatening stimuli and found that the group trained to attend to threatening stimuli reported greater anxiety in a later difficult anagram task compared to the group trained to attend away from threat. In this sense, anxiety results directly from the acquisition of attentional biases towards threat.

Research has not yet resolved the causal direction of the relation between anxiety and attentional biases, leaving this issue empirically ambiguous. Although this review will not focus on the issue of causality in attentional biases towards threat, we hope to facilitate future research in this area by elucidating the specific phenomenological features of attentional biases towards threat. Other researchers may then test the different specific features of attentional biases for causal or consequential roles in anxiety. For example, MacLeod and colleagues (2002) trained the facilitated attention towards threat feature of attentional biases and found that this feature may cause later anxiety. Subsequent studies may address whether other features of attentional bias also cause anxiety or whether the causal relation between attentional bias and anxiety is specific to the facilitated attention feature.

There are additional clinical implications of elucidating the specific features of attentional biases towards threat in anxiety. If attentional biases are indeed initially dependent on anxious responding and subsequently help maintain anxiety (e.g., Mogg & Bradley, 1998; Öhman & Wiens, 2005), then attentional biases could be used as an index of the degree to which a stimulus or class of stimuli elicits anxiety. Should separate phenomenological features of attentional biases towards threat differentially predict anxiety (e.g., facilitated attention may be a better index of anxiety than difficulty in disengagement), future researchers may wish to employ these tasks as objective measures of anxiety. Alternatively, if attentional biases cause anxiety (MacLeod et al., 2002; Mathews & MacLeod, 2002),

knowledge of the specific phenomenological features of attention towards threat will clarify precisely which features cause anxiety, thus facilitating treatment of anxiety through specific attentional manipulation.

3. Common assessment tasks used to measure attentional biases

3.1. The Posner paradigm

In the Posner paradigm (Fox et al., 2001; Posner, 1980), participants focus on a fixation point located between two rectangles. A cue is then presented (e.g., a threatening stimulus appears in one of the rectangles), followed by the appearance of an asterisk in one of the two rectangles. Participants are asked to press a key indicating the rectangle in which the asterisk is located. Some of the trials are valid cues (the cue draws attention to the rectangle with the asterisk), some of the trials are invalid cues (the cue draws attention away from the rectangle with the asterisk), and some of the trials are uncued (no cue occurs). Faster probe detection on validly cued trials when the cue is threatening compared to neutral suggests facilitated attention to threatening cues, in that the threatening cue draws attention toward the location where the probe will be more quickly than neutral cues, resulting in faster detection times. Alternatively, slower probe detection during invalidly cued trials when the cue is threatening compared to neutral suggests difficulty in disengagement in that the threatening cues hold attention away from the location of the probe. Thus, the Posner paradigm allows for an investigation of both facilitated attention towards threat and a difficulty in disengagement from threat.

3.2. The visual search task

In the visual search task (e.g., Öhman, Flykt, & Esteves, 2001; Rinck, Becker, Kellermann, & Roth, 2003), participants are directed to detect a target stimulus that is embedded in a matrix of distracting stimuli. For example, the target word “spider” might be displayed in a matrix (e.g., 3 row × 3 column pattern of stimulus presentation) of neutral distracter words. Conversely, a neutral target word may be embedded in a matrix of spider related words. Facilitated attention is indicated by quicker times to detect threatening targets in a matrix of neutral distracters compared to neutral stimuli in a matrix of neutral distracters. Difficulty in disengagement is reflected in slower times to detect neutral targets that are embedded among threatening distracters compared to times required to detect neutral stimuli in matrices of neutral distracters. Thus, the visual search task allows for an investigation of both facilitated attention towards threat as well as difficulty in disengagement from threat.

3.3. The dot probe task

The dot probe task was developed by MacLeod, Mathews, and Tata (1986) for the purpose of measuring attention to threatening stimuli. In this task, two words are displayed on a computer screen with one at the top and one at the bottom. Early versions of the task (e.g., MacLeod, Mathews, & Tata, 1986) had participants read the top word aloud. This focused the participant’s attention on the top word and after 500 ms, both words would disappear and a probe (‘*’) would appear in the location of either the top or bottom word. Participants were asked to press a button as soon as they detected the probe. Later versions (e.g., Koster, Crombez, Verschuere, & De Houwer, 2004; Mogg, Bradley, de Bono, & Painter, 1997) begin with a fixation cross displayed in the middle of the screen, with words or images displayed at the top and bottom of the screen. Following 500 ms of stimulus presentation, one of the stimuli is replaced with a probe. The participant is asked to press a button indicating whether the top or bottom stimulus had been replaced by a probe (i.e., a probe location task instruction), or indicate the type of probe displayed (i.e., a probe identification task; see Mogg & Bradley, 1999; Salemink, van den Hout, & Kindt, 2007). Attentional biases in all versions are inferred from different response times towards probes that replace

threatening stimuli compared to probes that replace neutral stimuli. Faster response latencies toward probes that replace threatening stimuli are thought to occur because the threatening stimuli have drawn attention to the spatial location occupied by the threatening stimulus, facilitating detection of the probe when it appears in that location. In contrast, slower times to detect probes replacing neutral stimuli, when neutral and threatening stimuli are paired together, is thought to suggest a difficulty in disengaging attention from threat.

3.4. The Stroop task

The modified Stroop task (Stroop, 1935) displays different types of words (e.g., threatening and neutral) in varying colors on a computer screen. The participant is asked to report the color—either verbally or by keypress—while ignoring the semantic content of the word. Heightened response times to report the color of threat words compared to neutral words are considered an indication of attentional biases. The Stroop task is theorized to require participants to inhibit the automatic and highly practiced act of reading in order to name the color of the characters (i.e., modulations of response inhibition; Algom, Chajut, & Lev, 2004; Williams et al., 1996). Attentional biases are inferred when the semantic content of the threat words results in greater difficulty inhibiting the act of reading (i.e., longer response latencies for color naming threat words) relative to words with neutral semantic content.

There are two common manipulations of the Stroop task: the masked Stroop task and the traditional unmasked Stroop task (e.g., Mogg et al., 1993). During the masked Stroop task, the stimulus is displayed briefly (e.g., 20 ms) and replaced by a backwards mask displayed in the same color as the original stimulus. The brief presentation time precludes conscious recognition of the word/characters and thus likely assesses automaticity. During the unmasked Stroop task, the stimulus is displayed continuously until the participant responds. Manipulations of stimulus duration allow for investigations of automatic versus strategic processing. Heightened latencies in the masked Stroop task indicate that the attentional bias occurred prior to conscious recognition of the stimulus and is thus automatic, while heightened latencies in the unmasked Stroop suggest the bias occurred following conscious recognition of the stimulus and thus reflects strategic processing. The Stroop task does not allow for an assessment of facilitated attention or difficulty in disengagement (also Fox, 2004 and Macleod et al., 1986) and may best be used as an index of automatic or strategic processing during attention.

3.5. Psychometric properties of attentional bias tasks

A paucity of research has examined the psychometric properties of tasks used to measure attentional biases towards threat. Extant research demonstrates poor test-retest reliability of bias scores (i.e., reaction time towards neutral words subtracted from reaction times to threat words) obtained in the Stroop and dot probe tasks (Kindt, Bierman, & Brosschot, 1996; Schmuckle, 2005; Siegrist, 1997). Eide, Kemp, Silberstein, Nathan, and Stough (2002), however, demonstrated high test-retest reliability of reaction times towards particular word classes in the dot probe (e.g., high reliability for emotional words; high reliability of neutral words), but low reliability of the bias score comprised of these reliable response latencies. Eide and colleagues argued that the bias score is an unreliable index, but the response latencies comprising the bias score are reliable over time. Extant research also demonstrates that attentional biases in the Stroop and dot probe do not correlate (Dalgleish et al., 2003; Gotlib et al., 2004; Mogg, Bradley, Dixon, Fisher, & McWilliams, 2000), suggesting that the tasks are measuring discrete processes (e.g., response inhibition in the Stroop, attentional allocation in the dot probe). Research has not yet examined the convergent validity of the other attentional bias tasks. Finally, different manipulations of the dot probe task including stimulus type (pictorial versus lexical) and task objective (i.e., a probe location task versus

probe identification task) have been found to produce similar results (Mogg & Bradley, 1999), while probe location tasks may produce greater attentional bias effects compared to probe identification tasks (Salemink, van den Hout, & Kindt, 2007). In sum, the psychometric properties of tasks used to measure attentional biases are questionable at best. As will be demonstrated in this review, however, results across the different tasks converge along a number of different lines that allow for conclusions to be drawn despite the questionable psychometric properties.

4. Facilitated attention towards threat, difficulty in disengagement from threat, or both?

One important characteristic of attentional biases is the facilitated manner with which threatening stimuli are detected (e.g., Fox et al., 2001; Öhman et al., 2001). This feature of attentional biases suggests that attention is drawn to the location of threat stimuli more quickly and easily than other stimuli. A second important characteristic of attentional biases is difficulty disengaging attention away from the location of threat stimuli, which may reflect an attentional holding phenomenon (e.g., Amir et al., 2003; Fox et al., 2001). This feature suggests that once attention is allocated toward a threat stimulus, attention will be difficult to divert onto another stimulus. Studies investigating these features of attentional biases towards threat have employed the Posner, visual search, and dot probe tasks.

4.1. Studies using the Posner paradigm

Research employing the Posner paradigm has revealed an interesting pattern of results. Some studies have only found difficulty in disengagement and no evidence for facilitated attention among individuals with high state anxiety (Fox, Russo, Bowles, & Dutton, 2001), high trait anxiety (Fox, Russo, & Dutton, 2002, experiment 1; Yiend & Mathews, 2001) and social phobia (Amir, Elias, Klumpp, & Przeworski, 2003). However, this consistent demonstration of difficulty in disengagement and failure to demonstrate facilitated attention is challenged by four studies demonstrating both facilitated attention and difficulty in disengagement.

Koster, Crombez, Verschuere, Van Damme, and Wiersema (2006) found that individuals with high trait anxiety demonstrated both facilitated attention and difficulty in disengagement toward highly threatening pictorial cues, but only difficulty in disengagement from threat for mildly threatening pictorial cues, both at a presentation time of 100 ms. Yet, at greater presentation durations (e.g., 200 ms and 500 ms), individuals with high trait anxiety showed enhanced attentional avoidance (i.e., attending toward the neutral stimulus and “avoiding” the threatening stimulus) for both highly threatening and mildly threatening cues.

The Koster et al. (2006) results emphasize the impact that both threat value and stimulus duration can have on conclusions about the phenomenological characteristics of attentional biases. Indeed, most studies mentioned above demonstrating only difficulty in disengagement (i.e., Fox et al., 2002, experiment 1; Yiend & Mathews, 2001; Amir et al., 2003) used presentation times of at least 250 ms. Moreover, the one study that did present threat stimuli for 100 ms stimulus duration (Fox et al., 2001; experiment 2) and found only difficulty in disengagement did not also manipulate threat intensity. The Koster and colleagues (2006) study is important, then, in that it brings to light the concept that attentional biases may exhibit different phenomenological characteristics as a function of time since stimulus onset (i.e., the time course of attentional biases towards threat) and degree of threat posed by the stimulus.

Koster and colleagues (2005; 2004) and Van Damme and colleagues (2006) used two different colored rectangles as cues, which prior to conditioning in a normal population showed no differential effects on attention. One of the rectangles (CS+) was subsequently conditioned to aversive stimuli (UCS; a noise burst was used in the Koster et al. studies, and a mild electrical shock was used in the Van Damme et al. study), while the other colored rectangle was not conditioned to the UCS (CS−). Following conditioning, results revealed faster response times on validly cued trials using the CS+ cue compared to the valid trials with the CS− cue. Response times were slower on invalidly cued trials using the CS+ cue compared to invalidly cued trials with the CS− cue. These results demonstrate both facilitated attention and difficulty in disengagement with stimuli that signal imminent danger.

Results from studies employing the Posner paradigm appear to emphasize the importance of methodological variables like stimulus duration and stimulus threat value (e.g., mild threat versus high threat) in determining the type of phenomenological feature revealed. At stimulus durations of 100 ms, both facilitated attention and difficulty in disengagement may be observed if the stimulus is highly threatening. At later stimulus presentations (e.g., greater than 200 ms), stimulus intensity may not be a factor and threat stimuli of any intensity may result in only difficulty in disengagement. Additionally, stimuli that signal imminent threat, such as CS+s used in conditioning procedures, appear to elicit both facilitated attention and difficulty in disengagement, again suggesting that intensely threatening stimuli elicit both of these phenomenological features of attentional biases. These results demonstrate that the type of phenomenological feature observed in the Posner is a function of the methodology used.

An important conceptual point illustrated by the results of studies employing the Posner paradigm is that both phenomenological features of attentional bias can co-occur, suggesting that the two features are not competing, but rather can complement one another. For example, there is no reason that the occurrence of facilitated attention must preclude subsequent difficulty in disengagement. An important limitation to the conclusion that both features can co-occur depending on Posner methodology is that only one research group (the Koster and Van Damme group) have explicitly manipulated important methodological features like stimulus duration and threat level to find these results. Until these results are replicated by independent researchers, firm conclusions from the Posner task are unwarranted.

4.2. Studies using a visual search task

Studies using the visual search task also yield somewhat inconsistent results, but the available data largely suggest that attentional biases are comprised of both facilitated attention and a difficulty in disengagement from threat. Some studies have found only difficulty in disengagement and not facilitated attention among individuals with GAD (Rinck, Becker, Kellermann, & Roth, 2003; experiment 1) and spider phobia (Lipp & Waters, 2007[1]; Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005; experiment 1). Alternatively, some studies have found only facilitated attention and no difficulty in disengagement among individuals with spider phobia (Flykt & Caldara, 2006[2]; Öhman et al., 2001; Pflugshaupt et al., 2005). However, these studies documenting only one phenomenological feature of attentional bias are contrasted by several studies that have observed both features concurrently.

[1]Lipp and Waters (2007) did not also test for facilitated attention. Therefore, their results do only demonstrate difficulty in disengagement but they do not rule out facilitated attention.

[2]Flykt and Caldara (2006) did not also test for difficulty in disengagement. Therefore, their results do only demonstrate facilitated attention but they do not rule out difficulty in disengagement.

Rinck and colleagues (2003; experiment 2) found evidence of both facilitated attention and difficulty in disengagement in the GAD group, though the facilitated attention effect was not as large as the effect for difficulty in disengagement. Rinck and colleagues (2005, experiments 2 and 3) used slightly modified visual search methodologies and found evidence of both facilitated attention and difficulty in disengagement among individuals with spider phobia. The results of Rinck et al. (2005) then suggest only difficulty in disengagement in the traditional visual search (experiment 1), but both facilitated attention and difficulty in disengagement in the manipulated versions of the visual search (experiments 2 and 3) among individuals with spider phobia. Miltner, Krieschel, Hecht, Tripp, and Weiss (2004) similarly found evidence of both facilitated attention and difficulty in disengagement among individuals with spider phobia across three experiments assessing both eye movement fixation and response times.

Lending further evidence to the hypothesis that the two features co-occur, some studies demonstrate effects for both facilitated attention and difficulty in disengagement using socially threatening stimuli among individuals with social phobia (Gilboa-Schechtman, Foa, & Amir, 1999) and high trait anxiety (Byrne & Eysenck, 1995). Interestingly, both of these studies found that socially threatening information results in both features of attentional bias in the high and low anxiety groups, though the features are exaggerated in those with higher trait anxiety or social phobia. Similarly, Juth, Lundqvist, Karlsson, and Öhman (2005, experiment 5) found evidence of facilitated attention towards schematic angry faces in both socially anxious and non-anxious individuals, as well as a difficulty in disengagement among socially anxious individuals who underwent a socially threatening mood induction. These studies converge in revealing both facilitated attention and difficulty in disengagement from socially threatening stimuli.

In sum, the majority of visual search tasks reveal both facilitated attention and difficulty in disengagement, although some studies have failed to find evidence of both features together. As mentioned with the Posner task, the dual demonstration of facilitated attention and difficulty in disengagement is important to note because facilitated attention and difficulty in disengagement do not need to be competing processes. The observation of the co-occurrence of the features across both the Posner paradigm and visual search tasks strengthens the conclusion that attentional biases towards threat are comprised of both facilitated attention and difficulty in disengagement.

Additionally, these studies indicate that similar attentional characteristics (both facilitated attention and difficulty in disengagement) are found among spider phobics towards spider-related threat stimuli as was found among socially and trait anxious individuals towards socially threatening stimuli. For those participants with GAD, indications for difficulty in disengaging from threatening lexical stimuli was strong, though there was some support for facilitated attention. The similar pattern of attentional characteristics across populations and stimulus classes suggests a robust pattern of attention towards threat.

4.3. Studies using the dot probe task

Attention towards threat has probably most extensively been studied using the dot probe paradigm. An extensive review of the dot probe literature is beyond the scope of this review (see Mogg & Bradley, 1998); rather we will focus on the ways in which the dot probe has been used to investigate the characteristics of attention to threat.

The most common finding reported with the dot probe is that of faster response times towards probes that replace threatening stimuli. For example, faster response times towards probes that replaced threat words compared to probes that replaced neutral words have been observed among individuals with high state anxiety (Mogg, Bradley, de Bono, & Painter,

1997), high trait anxiety (Bradley, Mogg, Falla, & Hamilton, 1998), GAD (Bradley, Mogg, White, Groom, & de Bono, 1999), and social phobia (Pishyar, Harris, & Menzies, 2004). These studies converge in revealing facilitated attention towards threat across several populations.

A method that has been used specifically to investigate the characteristics of attention to threat in the dot probe is the bias score (e.g., Bradley et al., 1998; MacLeod & Mathews, 1988). This bias score is calculated by subtracting response times to probes replacing a threatening target displayed with a neutral target (i.e., congruent trial) from response times to a probe replacing a neutral target when displayed with a threat target (i.e., incongruent trial). Positive bias scores reflect faster detection times for probes that replace threat targets relative to detection times for probes that replace neutral targets. Positive bias scores are interpreted as reflecting facilitated attention, in that threatening targets draw attention to the location where the probe will occur, resulting in faster reaction times. Negative bias scores reflect faster detection times for probes that replace neutral words relative to detection times for probes that replace threatening words. This is interpreted as evidence of orienting attention away from threat; or attentional avoidance (attentional avoidance as a characteristic of attention to threat is discussed later in this review). For example, Bradley et al. (1998) found positive bias scores for individuals with high, but not low trait anxiety, indicating facilitated attention towards threat, whereas Chen, Ehlers, Clark, and Mansell (2002) found negative bias scores among a socially anxious sample, indicating that socially anxious individuals orient attention away from threat.

The conclusion that the dot probe typically reveals facilitated attention is potentially flawed due to methodological and analytical problems (e.g., Fox, 2004; Koster, Crombez, Vershuere, and De Houwer, 2004). Analyses typically compare detection times to congruent trials against times to incongruent trials. An alternative analysis is assessing bias scores. The problem is that these techniques lack a baseline around which the data is centered. That is, the methodology employed does not allow for data to be collected on neutral targets replaced by probes on trials in which only neutral targets occur. Response times on this type of trial would provide a baseline level of attention. Response times on congruent trials could be compared to this baseline to assess for facilitation and response times on incongruent trials could be compared to the baseline to assess for difficulty in disengagement. Without a baseline against which the other responses can be compared, the data lack a centering point and it is unclear as to what faster or slower times mean in relation to baseline attention.

Koster et al. (2004) provided empirical support for a reanalysis of dot probe methodology. They compared congruent trials (i.e., trials in which the probe replaced the threatening stimulus when that stimulus was displayed with a neutral stimulus) and incongruent trials (i.e., trials in which the probe replaced the neutral stimulus when the neutral stimulus was displayed with a threatening stimulus) to trials in which only neutral stimuli appeared in a non-clinical sample. This comparison essentially created a neutral baseline against which the responses towards threatening stimuli can be compared. Results revealed that response times in trials with only neutral stimuli did not differ from response times in congruent trials, which fails to support facilitated attention to threat. Response times in trials with only neutral stimuli were faster than response times in incongruent trials, demonstrating a difficulty in disengagement of attention from threatening stimuli. Additionally, recent research employing similar dot probe methodology demonstrates only difficulty in disengagement among individuals with high trait anxiety (Koster, Crombez, Verschuere, & De Houwer, 2006; Salemink et al., 2007). Thus, when the dot probe methodology includes a baseline measure, the results suggest difficulty in disengagement and not the popular facilitated attention interpretation.

In conclusion, there are multiple ways of implementing the dot probe and recent methodologies (Koster, Crombez, Verschuere et al., 2004) have found empirical support for difficulty in disengagement as opposed to the commonly interpreted facilitated attention. Indeed, Fox (2004) similarly noted the methodological and analytic inconstancies in dot probe research and suggested that the dot probe probably reveals difficulty in disengagement. Based on the methodological, computational, analytical, and conceptual problems raised in this review and elsewhere (Fox, 2004; Koster, Crombez, Verschuere et al., 2006; 2004; Salemink et al., 2007), research using the dot probe task without including trials assessing baseline attention can only suggest that attentional biases are present and cannot elucidate the specific type of bias observed.

4.4. Summary

Research investigating whether attentional biases are comprised of facilitated attention and/or a difficulty in disengagement has yielded mixed results both within and between assessment tasks. Despite the trend of inconsistencies, some patterns have emerged. First, the methodology by which the dot probe is typically used suffers considerable limitations in elucidating the phenomenological characteristics of attentional bias, limiting conclusions that can be drawn from that line of research. Second, the visual search task most frequently reveals evidence of both facilitated attention and difficulty in disengagement. Indeed, there are only three methodologically sound studies that fail to reveal both features (Pflugshaupt et al., 2004; Rinck et al., 2005, experiment 1; 2003), compared to eight studies (Byrne & Eysenck, 1995; Gilboa-Schechtman et al., 1999; Juth et al., 2005; Miltner et al., 2004, experiments 1–3; Rinck et al., 2005, experiments 2 and 3) that found both features operating together. As such, a tentative conclusion that the visual search task reveals evidence of both features is warranted. Third, results from the Posner task suggest that the type of phenomenological feature observed is a function of the methodology employed. Both facilitated attention to threat and difficulty in disengagement from threat have been demonstrated with highly threatening stimuli (or indications of imminent threat) when displayed at brief (100 ms or less) durations. Results from the Posner task, then, also tentatively suggest that both features can co-occur. Despite the inconsistencies, then, it appears as though results from the visual search task and Posner task allow a conclusion that attentional biases are comprised of both facilitated attention and difficulty in disengagement. If both characteristics co-occur, it likely means that facilitated attention occurs first followed by subsequent difficulty in disengagement (i.e., attention cannot be difficult to disengage *before* it is allocated to the stimulus in a facilitated manner).

In regards to the inconsistencies observed, the studies cited above differ on numerous dimensions, including disorder (e.g., social phobia versus panic disorder), sample (clinical versus subclinical versus nonclinical), stimulus type (e.g., lexical versus visual), threat value of stimulus (i.e., how well do the stimuli sample the participants' domain of threat?), as well as stimulus duration. These are important moderating variables, as they may affect the type of attentional bias characteristic observed. Indeed, previous research has demonstrated the moderating effect of stimulus duration (Koster et al., 2006; Koster, Verschuere, Crombez, & Van Damme, 2005; Mogg, Bradley, Miles, & Dixon,2004) and threat intensity (Koster et al., 2006; 2005; 2004; Mogg et al., 2004). For example, Wilson and MacLeod (2003) found that both high and low trait anxious individuals exhibited attentional biases towards highly threatening stimuli in the dot probe task, though only high trait anxious individuals exhibited attentional biases towards mildly threatening stimuli. As can be seen, these moderating variables need to be quantitatively addressed in order to resolve the inconsistencies and determine if the type of phenomenological characteristics observed depends on the value of these moderating variables (e.g., threat intensity and stimulus duration).

Another problem with attentional bias research is the lack of consensus in operationalizing attentional biases. Some studies define attentional biases as the presence of differential responding towards threat and neutral stimuli in one group (typically an anxious group) and the absence of differential responding in the other group (typically a control group). For example, some studies report attentional biases as differences in response times towards threat stimuli compared to neutral stimuli only in the anxiety group without reporting if the anxiety group differs from the control group (e.g., Fox et al., 2002; 2001). Conversely, other studies demonstrate both between-group and within-group differences in response times toward threatening stimuli compared to neutral stimuli (e.g., Amir et al., 2003).

Reporting either only within-group differences or both within- and between-group differences has important implications for the types of conclusions that can be reached regarding attentional specificity among clinically anxious groups. For example, the results of Amir et al. (2003) show that all participants exhibit difficulty in disengagement, but that this effect is enhanced among socially anxious individuals. This does not suggest diagnostic specificity, but rather suggests that clinical participants exhibit natural attentional processes to a greater degree than non-clinical individuals. The results of Fox et al. (2001), however, reveal that only high trait anxious individuals exhibit differential attention towards threat versus neutral stimuli, suggesting attentional bias specificity among highly anxious individuals. Two very different theoretical conclusions can be drawn from these two methods of defining attentional bias: that biases in attention exist in all populations and are exaggerated among anxious individuals, or that attentional biases toward threatening information exist solely among anxious individuals.

We propose that attentional biases towards threat be operationally defined as differential attention towards threatening compared to neutral stimuli. This definition does not assume diagnostic specificity, diagnostic non-specificity, or diagnostic extremity, and thus the demonstration of attentional biases is not confounded by other empirical questions. Failure to reveal between-group differences in the degree to which attention differs towards threat compared to neutral stimuli will therefore not be a failure to reveal attentional biases, but rather a failure to reveal diagnostic specificity of the observed attentional bias. Conversely, revealing between-group differences in the degree to which attention towards threat and neutral stimuli differs will presumably reveal that attentional biases are more extreme in clinical individuals. Similarly, failing to reveal attentional biases as we define it in a control group but revealing attentional biases in the clinical group will be evidence of diagnostic specificity. Thus, researchers can use the operational definition proposed here to test diagnostic specificity versus extremity of attentional biases.

5. Automatic or strategic phenomenon?

Another question surrounding the phenomenon of attentional biases is the stage of cognitive processing during which these biases are postulated to occur. Automatic attentional biases refer to biases that occur without conscious recognition of the stimulus (i.e., the participant cannot report the stimulus) and strategic biases refer to biases that occur with conscious recognition of the stimulus (e.g., Bradley et al., 1995; Buckley, Blanchard, & Hickling, 2002; McNally, 1995; Mogg et al., 1995; 1993). A more detailed analysis of the stage of processing during which attentional biases occur facilitates a more detailed analysis of the phenomenology of the construct of anxiety. Additionally, understanding the stage of processing during which attentional biases occur may inform clinical interventions for anxiety (see Beck & Clark, 1997 and McNally, 1995 for a discussion of the clinical implications of automaticity in anxiety). The most popular method to date for investigating whether attentional biases are automatic or strategic is assessing performance on the masked

versus unmasked Stroop task. Less commonly, the dot probe has also been used to investigate this research question.

5.1. Studies utilizing samples with clinical or sub-clinical psychopathology

Several studies have investigated automatic versus strategic processing using both the masked and unmasked versions of the Stroop task. Bradley, Mogg, Millar, and White (1995) and Mogg and colleagues (1993) found increased response times for threat words compared to neutral words in both masked and unmasked tasks among a sample of individuals with GAD without comorbid depression. Thus, the authors found evidence of both automatic and strategic processing among a GAD sample. Similar findings of both automatic and strategic attentional processes have been replicated in posttraumatic stress disorder (PTSD; Harvey, Bryant, & Rapee, 1996), spider phobia (van den Hout, Tenney, Huygens, & de Jong, 1997) and high trait anxiety (van Honk et al. 2001, experiment 2). Interestingly, Kyrios and Iob (1998) found evidence of attentional biases in the masked task among individuals with Obsessive Compulsive Disorder (OCD), but found *reduced* (i.e., faster) response times towards threat words relative to neutral words in the unmasked task.

Evidence for both automatic and strategic attentional biases has also been found using the dot probe (see Mogg & Bradley, 1998). Mogg, Bradley, and Williams (1995) found attentional biases towards both masked and unmasked threat among the trait anxious group, thus demonstrating biases at both the automatic and strategic level. Similarly, Mogg, Bradley, and Hallowell (1994) found evidence of both automatic and strategic attentional biases towards threat among individuals with high trait anxiety, but the strategic bias only occurred under a prolonged state of stress (i.e., during examination week). Thus, data from both the Stroop and dot probe tasks reveal evidence of both automatic and strategic attentional biases.

Additional research has used the dot probe (Koster, Verschuere, Crombez, & Van Damme, 2005) and Posner task (Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006) to investigate automatic versus strategic biases in attention to threat, but these studies did not mask the stimuli (i.e., the lowest presentation times were 100 ms duration) and consequently could not control conscious awareness. Thus, if automatic processing is defined as responding before conscious awareness of the stimulus, then these latter studies cannot speak to the current question of automatic or strategic phenomena.

5.2. Studies examining the predictive ability of automatic and strategic attentional biases

Further suggesting the robust contribution of automatic processing in attentional biases are studies examining the degree to which automatic and strategic biases predict emotional responding to various types of stressful events among non-clinical individuals. MacLeod and Hagan (1992) found that the degree of masked Stroop interference predicted the degree of general dysphoric, anxiety, and depressive reactions among women about to undergo a cervical exam, but the unmasked Stroop task did not predict any type of emotional response. Similarly, van den Hout, Tenney, Huygens, Merckelbach, and Kindt (1995) found that masked Stroop interference predicted the degree to which participants expected aversive emotional reactions to varying hypothetical scenarios presented by the experimenters, but that unmasked Stroop interference did not. Nay, Thorpe, Roberson-Nay, Hecker, and Sigmon (2004) found that both masked and unmasked attentional biases in the Stroop predicted emotional responding during a biological challenge task among non-selected participants, thus providing the only evidence of strategic biases predicting emotional responding. These studies suggest that automatic attentional biases to threat are more robustly related to actual emotional responding compared to strategic attentional biases, thus suggesting that biases at the automatic level may be more integral to emotional responding.

5.3. Summary

A large body of data (e.g., Bradley et al. 1995; Harvey et al., 1997; van den Hout et al., 1997) investigating automatic versus strategic processes in attentional biases yield results suggesting that both types of processes operate in the phenomenology of attentional biases. Similar to our conclusion regarding the facilitated attention versus difficulty in disengagement research, there is no reason that automatic biases should preclude strategic biases or vice versa. It is important to note, however, that because the dependent variable in the Stroop and dot probe tasks is response time, the unmasked Stroop and dot probe tasks can only reveal that *something* has happened, not what has happened or when, allowing for the possibility that some automatic processing temporally preceded strategic processing. The masked Stroop and dot probe tasks, however, demonstrates better experimental control in that the backwards mask precludes the ability of participants to report the threat stimulus. Therefore, any attentional differences must have occurred at the preconscious, or automatic, level. Given this interpretation of the Stroop and dot probe tasks, the demonstration of unmasked attentional biases does not necessarily mean that the bias occurred because of strategic processing. As such, the results from this line of research strongly suggest automatic biases, but only show moderate support of strategic processing.

Some methodological limitations in the Stroop task may qualify the strength of these conclusions. Inconsistencies have been found in Stroop task research, specifically in that some studies have failed to reveal biases in the masked Stroop task among individuals with PTSD and panic disorder (PD; Buckley et al., 2002), spider phobia (Thorpe & Salkovskis, 1997), and snake phobia (Wikström et al., 2004). Given the ample evidence suggesting automatic biases, the occasional failure to detect biases at the automatic level may then reflect the methodological difficulty in conducting masked Stroop research. That is, there are individual differences in the duration at which a stimulus needs to be presented in order to be undetectable (e.g., some individuals may detect the stimulus at 34 ms, some may be longer). As such, researchers need to employ awareness checks and remove cases where the participants may have been able to detect the allegedly unconscious stimuli. Similarly, some researchers have failed to reveal attentional biases in the unmasked Stroop task (Devineni, Blanchard, Hickling, & Buckley, 2004; Moritz et al., 2004). Given the inconsistencies in the Stroop task research, it may be the case that the Stroop task is not sensitive enough to consistently reveal strategic biases when they are present. Nevertheless, the demonstration of automatic and strategic biases in the dot probe (e.g., Mogg et al., 1995) suggests that findings of automaticity from the Stroop task generalize to another measure of these particular phenomenological characteristics of attentional bias. Despite difficulties in drawing strong conclusions solely from the Stroop task, the converging evidence from another task strengthens the conclusion that attentional biases towards threat operate at both strategic and automatic levels of processing.

In contrast to the inconsistencies in the operationalization of attentional biases in the visual search, Posner paradigm, and dot probe studies, studies employing the Stroop task operationalize attentional biases in a more consistent fashion. However, Sawchuk, Lohr, Lee, and Tolin (1999) found increased response times for threat words compared to neutral words in both high and low BII phobic individuals, but failed to find a between-group difference and concluded that their results did not reveal attentional biases among BII individuals. Sawchuk and colleagues' conclusion is a good demonstration of the question of diagnostic specificity confounding the question of attentional phenomenology. Such issues strengthen the validity of our proposal to separate the definition of diagnostic specificity from the definition of attentional biases, and instead solely define attentional biases towards threat as differential attention towards threat compared to neutral stimuli.

6. General summary of the phenomenological characteristics of attention to threat

In sum, although our review reveals inconsistencies in regards to the phenomenological characteristics of attentional bias towards threat, trends have emerged that provide promising evidence from which to draw conclusions. First, results from the visual search and Posner tasks suggest that both facilitated attention and difficulty in disengagement can co-occur and are not competing attentional processes. It should be noted, though, that these results from the Posner task are dependent on specific methodologies in which the stimulus is highly threatening and displayed for 100 ms or signals imminent threat. In any case, the observation of co-occurrence between the features in more than one assessment task suggests generalization of the co-occurrence and strengthens the conclusion that attentional biases are comprised of both features.

Second, numerous studies using the Stroop task and a few studies using the dot probe task provide promising evidence to conclude that attentional biases towards threat operate at both the automatic and strategic level. Although some studies have failed to find masked interference in the Stroop task or any evidence for an attentional bias, the validity and reliability problems with the Stroop task are assuaged with the converging evidence of biases at the automatic and strategic level of processing in the dot probe task. As with the visual search and Posner tasks, the observation of automatic and strategic biases in both the Stroop and dot probe tasks suggests generalization of the phenomenon and strengthens the conclusion that biases operate at both levels of processing.

Our review suggests that attentional biases are comprised of facilitated attention towards threat, difficulty in disengagement away from threat, automatic processing, and strategic processing. These conclusions indicate that questions of ‘either/or’ in regards to these aspects of attentional biases should be replaced by questions of ‘when.’ That is, some research suggests that the specific feature of attentional bias observed may be a function of time since stimulus onset. We recommend that researchers continue this line of research and attempt to elucidate a temporal description of attentional biases towards threat. Researchers may wish to conceptualize facilitated attention versus difficulty in disengagement as a function of whether the stage of processing is automatic versus strategic. For example, automatic processing and facilitated attention may overlap, while strategic processing and difficulty in disengagement may be more temporally connected.

Research in pursuit of a temporal description of attentional biases towards threat may also wish to incorporate the observation of attentional avoidance. Attentional avoidance of threatening stimuli appears to happen secondary to facilitated attention and difficulty in disengagement (e.g., after 500 ms; Koster et al., 2006; 2005). Research revealing evidence of attentional avoidance has typically employed the dot probe paradigm with a stimulus duration of 500 ms (e.g., Chen & Ehlers, 2002). As mentioned earlier, typical dot probe methodology does not allow for comparison against baseline attention, and a static presentation time of 500 ms cannot rule out that other attentional features occurred prior to the attentional avoidance. Thus, research investigating the attentional avoidance hypothesis must investigate it as a function of stimulus duration. Research employing this methodology has revealed evidence for what is termed the vigilance-avoidance hypothesis (Garner, Mogg, & Bradley, 2006; Koster et al., 2006; 2005; Mogg et al., 2004; 1997), which posits that attention is initially oriented to threat, but subsequently attention is oriented away from threat in order to prompt escape from the threatening stimulus or to reduce anxious or fearful affect (e.g., Mogg & Bradley, 1998). The Koster and colleagues (2006) findings of facilitated attention and difficulty in disengagement in the Posner task at 100 ms stimulus duration, but attentional avoidance at 500 ms is consistent with this hypothesis. The

observation of differential attentional characteristics as a function of time since stimulus onset across both the dot probe and Posner tasks suggests generalizability and robustness of the phenomenon. Explicit in this model is the differential attentional characteristics as a function of time since stimulus onset, which highlights the overarching theme of examining a temporal description of the characteristics of attention to threat.

Finally, researchers testing a temporal model of the features of attentional bias may benefit from testing the ability of the different features at different stimulus durations to predict emotional responding (cf. MacLeod & Hagan, 1992). Research along this line would address the question of which aspects of attentional bias are more strongly related to actual emotional responding, and thus which features may be most relevant for clinical intervention. For example, facilitated attention 100 ms after stimulus presentation may best predict behavioral avoidance, thus suggesting that modification of facilitated attention at this level of processing (cf. MacLeod et al., 2002) may have the biggest impact on behavior. Research testing differential predictive ability of the different features of attentional bias would also guide future researchers towards more clinically useful methods. For example, if difficulty in disengagement at 500 ms is not predictive of other aspects of anxious responding, future clinically-oriented research may benefit from focusing on the aspects of attentional bias that are related to emotional responding.

7. What does this review say about the theories of information processing?

The current proposal of a temporal model has important implications for extant theories of anxious responding to threat, in that information processing models of anxiety have thus far only partially addressed the questions posed in this review regarding the phenomenology of attentional biases. There is general theoretical agreement that attentional biases occur primarily at a preconscious or automatic level, as demonstrated in models posed by Mogg and Bradley (1998), Mathews and Mackintosh (1998), Williams et al. (1988, 1997), and stage one of Beck and Clark's (1997) model. Several of these models consider attentional biases as composed of steps between the initial registration of a stimulus and the attentional response. For example, Williams et al. (1988, 1997) and Mogg and Bradley (1998) propose two separate systems that function in anxious responding. An initial system is responsible for a rough evaluation of the degree of threat a stimulus poses, in almost dichotomous positive or negative terms. A subsequent and related system then allocates attentional and other resources according to stimulus demands. Both Williams et al. (1988, 1997) and Mogg and Bradley (1998) suggest that both steps of this process—the registration and allocation systems—operate outside of conscious control. Similarly, Beck and Clark (1997) propose a three-stage model of the cognitive processing of threat-related information, the first stage of which is a simple registration of a stimulus as either positive or negative and as either personally relevant or irrelevant. Subsequent steps in the Beck and Clark (1997) model utilize a mixture of automatic and strategic processing for anxious responding. Mathews and Mackintosh (1998) also suggest the possibility for both automatic and strategic processing in response to threatening stimuli. These models agree then, that at least the initial registration of the valence or threat value of a stimulus is automatic and outside of conscious control. The actual system or mechanism responsible for shifting attention from the status quo and onto the threatening stimulus is either wholly a function of automatic processing (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Williams et al., 1988, 1997) or a mixture of automatic and strategic processing (Beck & Clark, 1997).

Less conclusive theoretically is whether attentional biases reflect facilitated attention toward threat or a difficulty in disengagement from threat. Contemporary models of information processing in anxiety tend to focus on explanations about the initial orientation toward a threatening stimulus, and fail to address subsequent engagement of attention. Mathews and

Mackintosh (1998) and Mogg and Bradley (1998) in particular rely exclusively on initial orientation to threat in their information processing models and do not attempt to explain additional aspects of the maintenance of attention. Mogg and colleagues (Garner et al., 2006; Mogg et al., 2004), however, recently have begun to suggest that attentional avoidance occurs following the initial orientation. Beck and Clark (1997) posit that threatening stimuli activate a "primal mode" (p. 52), which in turn results in a constriction of cognitive processing onto the threatening stimuli. This narrowed focus on the threatening stimuli may then result in a difficulty in disengaging attention away from the threat and onto more adaptive environmental cues. Although current theory has begun to incorporate the characteristics of attentional biases towards threat as a function of time, no current theory provides a detailed temporal description of each feature and their interaction (e.g., automatic and facilitated attention versus strategic and difficulty in disengagement).

The current empirical review suggests that any theory of information processing and attentional biases needs to account for each of the phenomenological characteristics and the interaction between characteristics (e.g., facilitated attention or difficulty in disengagement as a function of level of processing and time since stimulus onset). The extant models of information processing and attentional biases appear to be in need of at least slight revision.

8. Recommendations for future research

1. Researchers should focus on a temporal description of attentional biases that includes each of the four features discussed in the present review. Moreover, researchers should test the ability of the different features at different stages of processing to predict actual emotional responding in order to elucidate the most clinically-relevant aspects of attentional biases.
2. There is a paucity of research on the psychometric properties of these assessment tasks. Such limited knowledge of the psychometrics of these tasks limits the degree of confidence researchers can have on data derived from the tasks. Future research should continue to investigate the psychometric properties of these tasks.
3. Attentional biases are operationalized differently throughout the literature (e.g., Amir et al., 2003; Fox et al., 2001; Sawchuk et al., 1999). We propose that attentional biases be defined as within-group differential attention towards threat compared to neutral stimuli (e.g., an anxious group showing differential attention to threat compared to neutral stimuli is an example of an attentional bias). This definition partials out the larger issue of diagnostic specificity and/or extremity from the issue of whether attentional biases are present.

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