Review

Generalized Anxiety Disorder, worry and attention to threat: A systematic review

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ABSTRACT

Among anxious populations, attention has been demonstrated to be preferentially biased to threatening material compared to neutral or other valenced material. Individuals who have high levels of trait worry, such as those with Generalized Anxiety Disorder (GAD), may be biased to threat but research has produced equivocal findings. This review aimed to systematically review the extant experimental literature to establish the current evidence of attentional bias to threat among trait worriers compared to healthy controls and other clinical populations. Twenty-nine published articles were included in the final review. There was strong evidence of a bias to threat among GAD patients compared to other groups and this was found across most experimental paradigms. Few studies had investigated this bias in non-clinical trait worriers. Among GAD patients this bias to threat was most strongly evidenced when visual threat material was in a verbal-linguistic format (i.e., words) rather than when in pictorial form (i.e., images or faces). The bias was also found across several domains of negative material, supporting the general nature of worry. Further research should look to examine the specific components of the threat bias in GAD, as well as investigating the bias to threat in trait worriers.

1. Introduction

The current review examines the extant literature on attentional bias to threatening stimuli among individuals with a diagnosis of Generalized Anxiety Disorder (GAD) or those with high levels of trait worry who do not have a diagnosis of GAD. The paper begins by highlighting the distinction between "bottom-up" and "top-down" processing before then defining worry itself. The paper also provides a discussion of the different mechanisms associated with attentional biases (i.e., engagement, disengagement, shifting) and then leads into a brief review of neurobiological evidence of threat biases and worry. The paper then discusses Hirsch and Mathews' (2012) cognitive model of pathological worry which focuses on information-processing biases (including attentional bias) and the role of attentional control in promoting uncontrollable worry, before reviewing in detail the literature on attentional bias to threat.

This paper is the first known review that systematically examines the empirical evidence of attentional bias to threat among individuals with GAD and/or pathological levels of trait worry. Although previous papers have examined trait anxiety more broadly, worry has not been specifically targeted for review. However, worry is an integral cognitive component of anxiety, which can interfere with information-processing directly (Hayes, Hirsch, & Mathews, 2008) and has been linked to

attentional bias to threat stimuli (Mathews & MacLeod, 2005; Williams, Mathews, & Hirsch, 2014). It also represents a cardinal feature of GAD, an anxiety disorder with often difficult to treat symptoms. Therefore, this review will examine the evidence base for attentional bias to threat in individuals with high levels of worry in order to offer important insights into our understanding of attentional bias in those suffering from GAD or pathological worry, to highlight directions of future research and areas for potential treatment innovation. Given the lack of previous reviews targeting this specific characteristic of anxiety, the current paper will aim to focus on the association only between worry and attentional bias to threat, rather than trying to identify the specific direction of the relationship. Indeed, the role of attentional bias in the development of anxiety is rather complex and beyond the remit of this current paper, as Van Bockstaele et al. (2014) eloquently highlighted that "the relation between attentional bias and fear and anxiety is best described as a bidirectional, maintaining, or mutually reinforcing relation." (page 682).

Visual attention can be captured by salient or distinctive information in everyday environments, such as a smiling face, a growling dog, or a speeding car. At a basic level, selective attention can be defined as "any cognitive operation that results in the selection of some information over other information" (Weierich, Treat, & Hollingworth, 2008, p. 988). This selection can be stimulus-driven, such as changes in

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perceptual events which may capture attention automatically (Franconeri & Simons, 2003), or can be more strategically controlled, such as avoiding certain stimuli in order to regulate emotion (Calvo & Avero, 2005). The former is often regarded as being mediated by sub-cortical "bottom-up" pathways designed to rapidly detect salient stimuli in the environment (Davis & Whalen, 2001), whilst the latter is believed to be regulated by "top-down" pathways located in more prefrontal cortex regions, associated with attentional control, working memory, and goal-driven behaviour (Miller & Cohen, 2001). One factor that may influence the selection of attention is the level of threat attached to the stimulus, which may bias individuals to attend to it over neutrally valenced stimuli in the environment (e.g., MacLeod, Mathews, & Tata, 1986). This preferential processing of threat is regarded as being evolutionarily adaptive (to monitor danger in the environment) (Ohman, 1986) and is thus applicable to most individuals, but it is more pronounced in anxious individuals compared to non-anxious populations (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Beck, Emery, & Greenberg, 1985; Mathews & MacLeod, 1994). This 'attentional bias' to threat among anxious populations is well established and may be implicated in the maintenance of anxiety symptoms (Yiend, 2010). However, the attentional system comprises several components and is modulated by multiple mechanisms and so understanding the distinct processes involved within attentional bias to threat among anxious individuals is warranted to inform clinical treatments (Bar-Haim et al., 2007; Cisler, Bacon, & Williams, 2009; Cisler & Koster, 2010).

Worry is a feature of most anxiety disorders (Beck & Clark, 1997), but in particular is the core criterion of Generalized Anxiety Disorder (GAD; Diagnostic and Statistical Manual 5th Edition, DSM-V; American Psychiatric Association, 2013). Worry is often associated with elevated feelings of anxiety, but is conceptually distinct, as anxiety is more broadly defined as including feelings of tension and autonomic arousal (Borkovec, Robinson, Pruzinsky, & DePree, 1983). Thus high worriers represent a subset of anxious individuals, for whom repetitive negative thoughts (typically in quasi-verbal form) are particularly prominent. Those with high levels of trait worry may experience negative health outcomes, regardless of whether or not they currently qualify for a GAD diagnosis (Brosschot & van der Doef, 2006). Consequently, it is important to identify factors that cause and maintain excessive worry, with attentional biases providing a possible avenue of research (e.g., Oathes, Siegle, & Ray, 2011). Although studies have found attentional bias to threat in GAD patients (e.g., Mogg & Bradley, 2005) and in high trait anxious groups (see Bar-Haim et al., 2007), less research has examined threat bias in non-clinical worriers, who represent an at-risk group for the development of GAD. Importantly, as will be discussed briefly later, investigations of emotional processing have revealed certain neural characteristics that seem to distinguish high worriers from non-worrying high trait anxious individuals (e.g. Engels et al., 2007; Paulesu et al., 2010).

Posner (1980) postulated three components of attention: engagement, disengagement, and shifting. Engagement refers to the orienting of the attentional resources on a particular stimulus, whilst shifting refers to the process of switching from one stimulus to another (Clarke, MacLeod, & Guastella, 2013). In order for shifting to occur though, the individual has to first disengage their attention from the current attended to stimulus. Clarke and colleagues defined biased engagement as "the rapid orientation of attention to a threat stimulus due to its enhanced ability to "capture" or "draw" attention" (2013, p. 3), whilst they defined biased disengagement as the "delayed withdrawal of attention from a threat stimulus due to its ability to "hold" attention" (2013, p. 3). Different methods have been used to assess attentional bias to threat in the anxiety literature, with each having advantages and disadvantages. Posner (1980) developed the spatial cueing task, which involves participants attending to a cue which is located in the same location as a to-be-identified target in the majority of trials and then in the remaining trials the target is in the opposite location (opposite to an

original fixation cross). This task was modified by Yiend and Mathews (2001) and Fox, Russo, Bowles, and Dutton (2001) who used different emotional cues (threat/neutral) to identify preferential processing of different emotional stimuli. This task is thought to detect biased engagement and delayed disengagement as inferred by speeded reactions to targets in valid trials (emotional cue and target in same location) and by delayed reactions to invalid trials (target in opposite location to emotional cue), respectively. Fox et al. (2001), Fox, Russo, and Dutton (2002) and Yiend and Mathews (2001) concluded from their use of this paradigm that attentional bias is primarily due to delayed disengagement from threat rather than facilitated engagement to threat. However, some believe that the task measures disengagement better than engagement (Cisler & Koster, 2010; Clarke et al., 2013) and has been criticised for not distinguishing between disengagement and a general behavioural slowing that occurs in the presence of threat (Mogg, Holmes, Garner, & Bradley, 2008; although see Yiend, 2010 for a critique of this). The affective Stroop task (Mathews & MacLeod, 1985) and the attentional probe task (MacLeod et al., 1986) have been commonly used, although other paradigms have also included the visual search task, which typically involves participants having to decide if a target stimulus is present or absent in the presence of distractor stimuli (Müller & Krummenacher, 2006); or the attentional blink task, where a stream of stimuli are displayed and respondents are required to identify a target presented shortly after the first target has been presented (Raymond, Shapiro, & Arnell, 1992).

The results of studies using these different tasks points to attentional bias to threat among anxious individuals in general, but it is unclear whether the bias to threat is a result of facilitated engagement, delayed disengagement, or impaired or biased shifting. This uncertainty is due to a lack of studies that have specifically distinguished the components of attentional bias (Bar-Haim et al., 2007) and the lack of reliability in the methodological designs to confirm the contribution of each component on attentional bias (Clarke et al., 2013). Further, research looking at the neural mechanisms underpinning attentional bias point to different neural networks and locations involved in the bias, as described below.

The attentional system and the regulation of emotion are regarded as operating through an interaction of the amygdala and cortical regions (Bishop, 2007; Blair & Blair, 2012; Cisler & Koster, 2010), which has also been reported in the context of individual differences in anxiety (Mathews, Yiend, & Lawrence, 2004). The initial rapid orienting of attention to threat is regarded as being relatively automatic and has been shown to be coordinated by sub-cortical structures, such as the amygdala (Davis & Whalen, 2001). However, most of the research cited above has not investigated the specific role of worry, as opposed to elevated state or trait anxiety, and current evidence indicates that elevated worry is distinguished by involvement of the so-called "extended Amygdala"; and specifically, the Base Nucleus of the Stria Terminalis or BNST, which is particularly active under conditions of uncertain threat (Paulesu et al., 2010: Yassa, Hazlett, Stark, & Hoehn-Saric, 2012).

Biased engagement of attention with threat cues is often shown at short stimulus exposures in most experimental paradigms (Sagliano, Trojano, Amoriello, Migliozzi, & D'Olimpio, 2014) suggesting a degree of automaticity in the initial capture of attention by threat cues. When a stimulus is exposed for longer durations then it falls within conscious awareness (i.e. is 'supraliminal') and it is generally assumed that at these longer stimulus exposures there are more top-down strategic (or controlled) processes contributing towards the allocation of resources (Cisler & Koster, 2010). These top-down processes are believed to be governed by frontal brain structures, such as the prefrontal cortex (Blair et al., 2012), which are involved in disengaging and selectively shifting attention (Miller & Cohen, 2001). As a result, there may be more variation in experimental findings when using supraliminal exposures, as individuals may have different attentional goals. For example, several studies have found a bias towards threat at later exposure

durations and concluded that it is due to delayed disengagement from threat, which may be due to an impaired ability to disengage attention from threatening material due to poor top-down attentional control (Derryberry & Reed, 2002) and/or it may represent an underlying emotion regulation strategy to remain focused on threatening information (Wells, 1995). Equally, though, other researchers have found biases *away* from threat among anxious individuals under supraliminal conditions, and have inferred that this is due to an attentional avoidance of threat (Mogg & Bradley, 1998), which is also governed by top-down processes.

The relative contribution of bottom-up and top-down pathways to attentional bias to threat is still not fully understood. Egloff and Hock (2003) concluded from their assessment of both the affective Stroop and attentional probe tasks that stimulus-driven (bottom-up) biases occurring rapidly in the attentional process (short stimulus exposures outside of conscious awareness) are distinct from biases that occur when stimuli are presented supraliminally, within conscious awareness (where there is opportunity for top-down control). Examination of the research literature on neural mechanisms underpinning attentional bias certainly indicates a more complex picture than simply top-down versus bottom-up processes, as briefly highlighted below.

Neural correlates of worry include activation of medial prefrontal and anterior cingulate regions as well as the BNST (Paulesu et al., 2010), consistent with the phenomenological pattern of thinking reported by high worriers. Similarly, Bishop (2007) concluded in her review of neurocognitive mechanisms of anxiety that amygdala-pre-frontal circuitry is likely responsible for biases to threat in anxious individuals. However, the exact location and/or pathways are unclear and it remains uncertain whether the same pathways are similarly involved in the processing of other emotional material (e.g. positive stimuli). For example, dorsolateral prefrontal cortex regions have been shown to mediate processing of positive, as well as threatening, material (Bishop, 2007; Herrington et al., 2005), whereas Miscovic and Schmidt (2010) concluded that variations in attention to threat was jointly accounted for by *right* frontal EEG asymmetry and low cardiac vagal tone. Furthermore, Clarke, Browning, Hammond, Notebaert and MacLeod (2014) demonstrated the role of the *left* dorsolateral pre-frontal cortex in modulating attentional bias to threat. This left-right difference between studies is likely due to the type of stimuli used, since Miscovic and Schmidt (2010) used facial stimuli and Clarke, Browning et al. (2014) used words, that presumably require more processing in the left-dominated language centres (Zatorre, Meyer, Gjedde, & Evans, 1996). This distinction is further supported by Avram, Baltes, Miclea, and Miu's (2010) study of anxious individuals using the Stroop task and EEG data. These authors found attentional bias to threat using facial stimuli that corresponded with greater *right* frontal activation.

The left versus right hemisphere processing of emotional material was specifically examined by Engels et al. (2007). These authors also distinguished between anxious apprehensive individuals (i.e. worriers) and others characterised more by high anxious arousal (with corre-sponding low worry) in their processing of threat information, and concluded that biased processing of threat words in worriers involved left frontal regions whereas in the latter group, bias involved right inferior temporal regions. Interestingly, Engels et al. (2007) also examined the role of left dorsolateral prefrontal cortex regions in processing positive versus negative information and concluded that among worriers there are distinct regions responsible for processing threat (inferior frontal gyrus) versus positive information (dorsolateral prefrontal cortex).

The above evidence of frontal involvement in attentional bias to threat is consistent with other findings of impaired control in anxious individuals (for example, when trying to disengage from threat). However, Eldar, Yankelevitch, Lamy, and Bar-Haim's (2010) ERP data demonstrated higher C1 amplitude (at around 80 ms stimulus onset asynchrony; SOA) in the anxious versus non-anxious group when responding to threat stimuli, suggestive of a biased early *engagement*

with threat. This biased engagement is more likely mediated by areas other than just the prefrontal cortex. However, the two processes are probably interlinked and operate alongside each other in contributing to threat-related attentional bias. Indeed, Pessoa (2005) has argued that there is considerable interdependence between stimulus-driven atten-tion to threat and top-down control, because demonstrating attention to threat actually depends upon the availability of top-down attentional resources (i.e. high levels of perceptual load can block the supposedly 'automatic' attention to threat distracters).

An alternative form of interaction between bottom-up and top-down processes in attentional bias was suggested by Hirsch and Mathews (2012) in their cognitive model of worry. Hirsch and Mathews (2012) reviewed evidence that trait worriers have an increased tendency to engage with threatening information than non-worriers and also have greater difficulty disengaging from it, either due to impaired attentional control ability or a goal-driven focus on threat. Such a goal-driven focus could arise from mistaken positive meta-cognitive beliefs about the benefits of worrying (Wells, 1995), for example, that worry is helpful in avoiding threats or solving problems. Alternatively, the difficulty in disengaging could reflect a reduced ability to redirect attention away to neutral or positive topics (Derryberry & Reed, 2002). It is possible that this poor attentional control is actually a product of the worry process itself (Hayes et al., 2008; Stefanopoulou, Hirsch, Hayes, Adlam, & Coker, 2014), which takes up attentional control resources in high worriers and those with a diagnosis of GAD, thereby reducing the attentional resources available to switch to non-worry topics (Klein & Boals, 2001). Leigh and Hirsch (2011) found substantially reduced attentional control resources in high worriers when they were worrying in their usual quasi-verbal form rather than thinking in the form of mental imagery. Thus the verbal nature of worry itself (Hirsch, Hayes, Mathews, Perman, & Borkovec, 2012) may be partly responsible for impaired control and to the special difficulty experienced when high worriers try to switch focus to other topics.

It is important to add that attentional bias to threat is just one potential information-processing bias associated with worry. In addi-tion, it has been previously demonstrated that worry is maintained in individuals with a diagnosis of GAD and among high worriers by their *interpretation* bias to threat (Hayes, Hirsch, & Mathews, 2010; Hirsch, Hayes, & Mathews, 2009). In fact, this interpretation bias is another key component of Hirsch and Mathews' (2012) cognitive model of worry described above. In their model, they highlight the fact that worriers will interpret ambiguous information in a threatening manner and as such the product of this interpretation will be threatening in nature and these thoughts will then form a focus for attentional bias. Therefore, although attentional bias may be influenced by potential attentional control deficits and/or positive beliefs about worrying (see above), it may also simply be that worriers and those with GAD are interpreting ambiguous stimuli as threatening more of the time than non-worriers and are subsequently directing their focus on this 'threat' material (Hirsch & Mathews, 2012). Although information-processing biases do not exist in isolation but will interact in important ways (Hirsch, Clark, & Mathews, 2006), for the purpose of the current review, bias of attention to threat will be the point of focus, in order to establish the hypothesised association with worry.

Attentional biases to threat have been found across a range of anxious populations, both clinical and non-clinical and have been implicated in the maintenance of anxiety disorders. Importantly, GAD, with its hallmark feature of worry, has been shown to often temporally precede other affective disorders and influence the subse-quent course and outcomes of these secondary conditions (Kessler, Keller, & Wittchen, 2001). Therefore, despite information processing biases being suggested to be important across anxiety disorders, it would be helpful to systematically review the evidence of attentional bias to threat in individuals with GAD and those with high levels of worry (without a diagnosis of GAD), since this may help inform our theoretical understanding of worry and GAD, as well as helping to guide

future treatment innovation.

1.1. Aims and objectives

This paper aims to systematically review experimental studies of attentional bias in individuals with high levels of trait worry only and as such, it excludes studies that recruited participants using measures of trait anxiety more broadly. Further, given that GAD has 'excessive worry' as a core criterion (American Psychiatric Association, 2013) this review will also include studies that have investigated samples of individuals with a diagnosis of GAD. It is widely believed that most organisms have evolved preferential processing of threatening versus neutral information so as to promote survival (Ohman, 1986). Hence simply identifying a bias favouring threat versus neutral information within GAD or high worry (GAD/worry) samples would not add to the current knowledge base. Rather, this review aims to determine if high trait worry samples have an exaggerated attentional bias to threat *compared to* healthy controls and/or other clinical populations. This bias will be identified by experimental paradigms rather than through associations between reported individual differences, as experimental paradigms provide a more objective measure of attentional bias than self-report measures and have established attentional biases in other anxious populations (Bar-Haim et al., 2007). Further aims are to then establish which aspects of empirical evidence moderate the GAD/worry attentional bias effect, asking the following specific questions:

- Do adults with GAD/worry (high trait worry) demonstrate increased attentional bias to threat compared to healthy controls?
- Does an attentional bias to threat among GAD/worry groups differ from those seen in other clinical groups?
- Is a similar attentional bias to threat among GAD/worry groups found across all experimental paradigms?
- Does any bias in GAD/worry groups vary at different stimuli exposure times, indicating predominantly bottom-up or top-down processing?
- Is bias in GAD/worry groups found with all types of threat stimuli (verbal-linguistic vs imagery; threat vs other emotional content valence; general threat vs specific threat)?

2. Method

2.1. Search strategy

The current systematic review conducted literature searches on PsycINFO and Medline in week 4 of October 2014, using the following search terms: *attention*; *attentional bias*; *worry*; *worrie**; *generalized anxiety disorder*; *anxiety disorders*; *anxiety*. Mapped terms and auto exploding of search results were used where available. The terms were then combined and studies limited to studies written in English and studying human samples only. Articles were retained if they fulfilled the following criteria outlined below. In addition, the reference lists of all retained articles as well as key review articles were searched for any additional articles that could be included in the current review. The search was re-run in Week 3 of April 2015 and Week 2 of February 2016 to incorporate any relevant newly published papers. Any articles where the decision to include them was uncertain were discussed with a second researcher experienced in the field (CH) and an agreement reached whether or not to include the article.

2.2. Inclusion criteria

Studies were included if they satisfied all of the following inclusion criteria:

- Any study published as a peer-reviewed journal article in English, AND;

- Any study which has investigated trait worriers (18–65 years old only), as defined by a recognised measure of trait worry (Penn State Worry Questionnaire; PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990), and/or individuals with GAD (or inferred via the use of a recognised measure of GAD) (e.g., GAD-Q; Newman et al., 2002), AND;
- Any study that has assessed attention to threat/negative stimuli in comparison to neutral/other valenced stimuli using an experimental paradigm, such as the affective Stroop task or the attentional probe task, AND;
- The outcome is a proxy measure of attention, such as response time (RT) latencies (as used in the attentional probe task).

2.3. Exclusion criteria

Studies were excluded if they fulfilled one of the following exclusion criteria:

- A GAD/worry group is not specifically identified (e.g., combined with individuals with other anxiety disorders within the same sample)
- Measures used for study inclusion are measures of trait anxiety as opposed to trait worry
- There is no non-GAD/worry comparison group
- Attentional bias is not assessed by an experimental task (i.e., if self-report is used only).

2.4. Quality assessment

Quality of the retrieved articles were assessed using a combination of the Q-Coh I and II (Jarde, Losilla, Vives, & Rodrigo, 2013), along with the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies (Thomas, Ciliska, Dobbins, & Micucci, 2004). The Q-Coh II is designed for cohort studies, although assesses quality across domains that are relevant for quasi-experimental designs used by the studies identified in the current review. These domains include assessment of selection bias (e.g., if studies used standard inclusion criteria), information bias (e.g., if studies used validated methods of assessment and outcome), performance bias (e.g., if the procedure was appropriate), and attrition bias (e.g., if the study reported or accounted for dropouts). The Q-Coh I asks similar questions to its successor, although for the current review only the representativeness question was retained (i.e., if the sample has been selected from a group that is representative of the population). The EPHPP measure also asks similar questions, but specifically for here, only the Statistical Analyses question was used, asking if the statistics and conclusions were appropriate. A key factor in assessing quality was the attention to detail of a study's design in controlling for relevant confounding variables, including gender, age, proxy measure of IQ/verbal ability, and depression, with a study deemed to have higher quality for controlling for the presence of these variables among their sample. Depression was included as a key confounder because research has shown that the presence of comorbid depression can obscure attentional bias findings in anxious populations (Bar-Haim et al., 2007; e.g., Mogg, Bradley, Williams, & Mathews, 1993).

3. Results

The search process can be seen in the PRISM Flowchart in Fig. 1. The searches resulted in 1933 articles in PsycINFO and 2471 articles in Medline (Medline search terms differed due to different abilities to 'explode' search terms between the two search databases). Therefore, the total number of articles returned was 4404, which was reduced to 3610 after duplicates were removed. Titles were then screened for relevance and 303 papers were retained for further inspection. Papers were screened using abstracts at this stage and were excluded if they
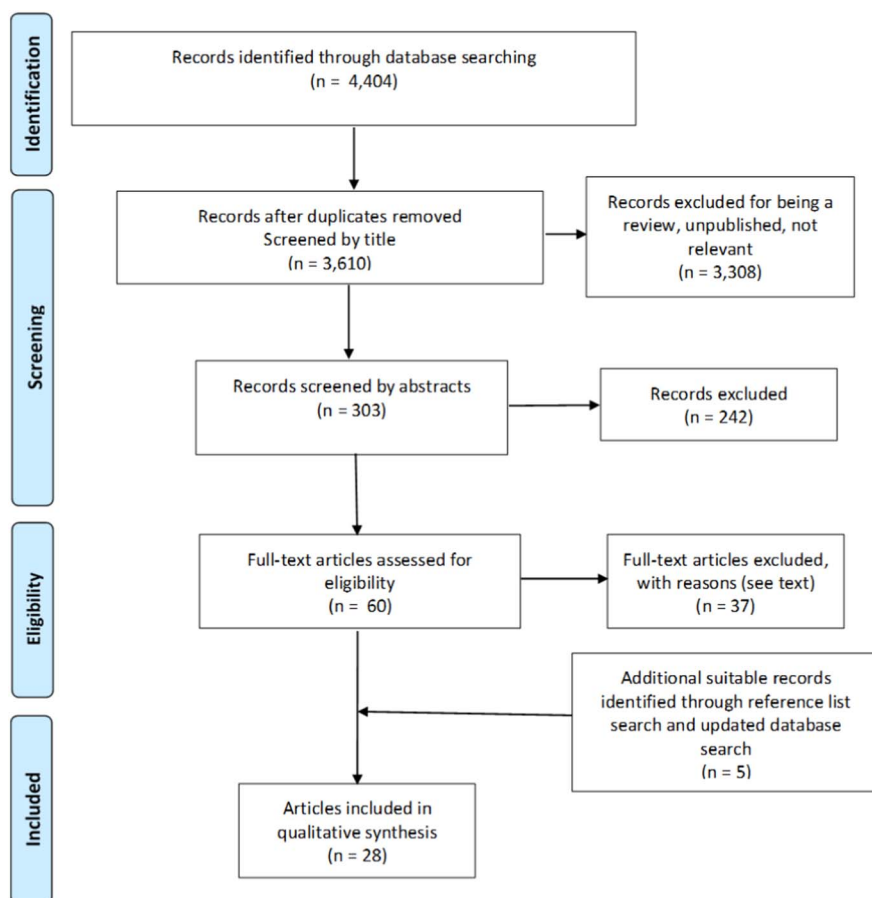
Fig. 1. PRISM flowchart of selection of papers.

were deemed irrelevant (e.g., they were not an experimental study of a GAD/worry population), if they were not published (i.e., a dissertation), or were a review paper ($n = 242$). The remaining articles' ($n = 61$) full texts were examined and articles were removed for any of the following reasons: a) not experimental or measuring attentional bias to threat ($n = 16$); b) did not have a clearly defined GAD/worry group ($n = 15$); c) did not have a comparison group ($n = 3$); d) any other reason that did not satisfy the inclusion/exclusion criteria listed above ($n = 3$). The remaining articles ($n = 24$) were then added to an additional five papers which were identified from reference list searches of relevant papers ($n = 4$) or from an updated database search ($n = 1$). This left a final number of 29 published articles, accounting for 32 separate studies. The studies' descriptions are in Table 1 and their relevant findings are summarised in Table 2.

3.1. Participant characteristics

The 32 studies accounted for 617 GAD/worry participants, 670 'healthy' controls, 58 speech phobia participants, 51 panic disorder participants, 65 non-clinically 'anxious' individuals, 36 'recovered' GAD individuals, 50 participants with clinical depression, and 11 participants with persecutory delusions. The studies' group of interest's (GAD/worry) size ranged from 11 to 42 participants, with significant findings being reported across the whole range of group sizes. The majority of studies recruited participants with a clinical GAD diagnosis ($n = 29$) as their study group of interest, with 21 studies reporting the use of a clinical interview to confirm the diagnosis. Seven studies did not report how the diagnosis was made and one study used a self-report online diagnostic questionnaire (MacLeod, Soong, Rutherford, & Campbell, 2007). Clinical interviews were often standardised interviews, including variants of the Structured Clinical Interview for the DSM (SCID;

First, Spitzer, Gibbon, & Williams, 1995), the Anxiety Disorders Interview Schedule (ADIS; DiNardo & Barlow, 1988), the International Diagnostic Checklists (Hiller, 1997), or the Mini-International Neuropsychiatric Interview (MINI; Sheehan et al., 1997). Only three studies used trait worry as the group of interest, with one study (Oathes et al., 2011) using a high score on the PSWQ as the inclusion criterion for high trait worry, and two studies using a combination of high and low scores on the PSWQ and Mood and Anxiety Symptom Questionnaire (MASQ; Watson & Clark, 1991) respectively to determine group membership (Engels et al., 2007; Sass et al., 2010). The studies' cut-off for 'high worry' differed between them, with Oathes et al. (2011) using > 55 and Sass et al. (2010) using > 62 on the PSWQ, for example.

Twenty-four studies did not report comorbidity among their sample. Of those studies who did report comorbidity among their GAD/worry group, additional comorbid diagnoses included affective and anxiety disorders. Three studies reported comorbid depression ranging from 45% to 57% ($M = 50\%$) among the GAD/worry groups. Seven studies reported their GAD/worry group to have a comorbid anxiety disorder, including specific phobia, social phobia, OCD, and/or Panic Disorder, with comorbid anxiety disorder prevalence in GAD/worry groups being at 27% on average.

The mean age of participants in GAD/worry groups was 38.67 years (from those studies who had stipulated age specific to their GAD/worry group; $n = 26$) and was 35.38 years in healthy control groups (from 25 studies). Three studies did not report gender distribution and two studies only reported it for the whole sample rather than within their experimental groups. For those that reported gender distribution within their GAD/worry group specifically, on average GAD/worry groups comprised 36% male participants, with gender distribution ranging from 0% male participants to 64% male participants. On average (from 22 studies that reported it), healthy control samples comprised 45%

Table 1
Systematic review study characteristics.

Study	Sample	M:F ratio	Age range mean (SD)	Ethnicity	Comorbidity
Albu, 2008	GAD Dx (n = 20) vs HC (n = 20)	GAD = 6:14; HC = 12:8	GAD = 49.45, HC = 45.15	Not reported	Not reported
Ashwin et al., 2012	GAD Dx (n = 18) vs PD Dx (n = 17) vs HC (n = 31)	GAD = 5:13; PD = 2:15; HC = 12:19	GAD = 32.06 (10.2); PD = 32.76 (9.22); HC = 29.26 (9.20)	Not reported	Not reported
Becker, Rinck, & Roth, 2001	GAD Dx (n = 32) vs Speech Phob Dx (n = 29) vs HC (n = 31)	GAD = 56.6% male; Speech Phob = 60% male; HC = 56.7% male	GAD = 44.3; Speech Phob = 46.2; HC = 45.2	GAD = 71% White, 12.9% Asian, 12.9% Hispanic; Speech Phob = 90% White, 6.7% Hispanic, 3.3% Asian; HC = 78.1% White, 9.4% Black, 6.3% Hispanic, 3.1% American Indian, 3.1% Asian	GAD: Specific Phob n = 4; Speech Phob: Specific Phob n = 8, PD n = 1; HC: Specific Phob n = 3
Blair et al., 2012	GAD Dx (n = 17) vs HC (n = 18)	GAD = 4:13; HC = 8:10	GAD = 34.9 (10.93); HC = 30.4 (6.86)	Not reported	"No other Axis I Disorders"
Bradley, Mogg, Millar, & White, 1995	GAD (ADIS-R; n = 20) (GAD only n = 11; GAD + Dep n = 9) vs HC (n = 20)	GAD only = 7:4; GAD + Dep = 5:4; HC = not reported	18–55 years	Not reported	GAD = 2 PD, 1 Social Phob; GAD + Dep = 1 PD, 1 Social Phob
Bradley, Mogg, White, Groom, & Bono, 1999	GAD Dx (n = 14) vs HC (n = 33)	GAD = 7:7; HC = 13:20	GAD = 36.4 (9.6); HC = 31 (11.6)	Not reported	GAD: Dep (n = 8; including 1 with PD and 1 with Social Phob); Social Phob (n = 3; including 1 with PD and 1 with Specific Phob)
Chen et al., 2013	GAD Dx (n = 42) vs PD Dx (n = 34) vs HC (n = 46)	GAD = 19:23; PD = 11:23; HC = 15:31	GAD = 34.33 (7.98); PD = 31.59 (8.58); HC = 31.07 (7.51)	Not reported	Not reported
Dibartolo, Brown, & Barlow, 1997	GAD Dx with PSWQ > 57 (n = 15) vs HC with PSWQ < 46 (n = 15)	20% male	36.13 (12.88)	Not reported	Not reported
Engels et al., 2007	Anxious Apprehension (Worry) (> 80th percentile on PSWQ AND < 50th percentile on MASQ; n = 11) vs Anxious Arousal (> 80th percentile on MASQ AND < 50th percentile on PSWQ; n = 13) vs Low Anx (< 50th percentile on both PSWQ and MASQ; n = 18)	Total = 18:24	18.71 (0.80)	Not reported	All participants scored < 50th percentile on depressed mood scale (MASQ-AD)
Freeman, Garety, & Phillips, 2000	GAD Dx (n = 12) vs Pers Delusions group (as assessed by SCAN-v10; n = 11) vs HC with STAI-T < 44 (n = 12)	GAD = 6:6; Pers Delusions = 8:3; HC = 9:3	GAD = 43 (10.6); Pers = 38.9 (12.7); HC = 40.8 (9.2)	Not reported	GAD: 6 secondary dep, 6 with additional anx disorder; Pers Delusions: 10 paranoid schizophrenia, 1 delusional disorder
MacLeod & Mathews, 1991	GAD Dx (n = 16) vs HC (n = 16)	GAD = 4:12; HC ratio not given	GAD = 36.4 (11.04); HC = 36.1 (10.1)	Not reported	Not reported
MacLeod et al., 2007	Self-reported GAD Dx (n = 24) vs HC (n = 35)	Not reported	Not reported	Not reported	Not reported
MacNamara & Hajcak, 2010	GAD Dx (n = 15) vs HC (n = 15)	GAD = 2:13; HC = 4:11	GAD = 33.53 (14.74); HC = 31.73 (11.20)	Not reported	GAD: Specific Phob (n = 2)
Martin, Williams, & Clarke, 1991; Exp 2	GAD Dx (n = 12) vs Anx Controls (n = 12)	GAD = 3:9; Anx Control = 0:12	GAD = 36.3; Anx Control = 28.4	Not reported	Not reported
Martin et al., 1991; Exp 4	GAD Dx (n = 12) vs HC (n = 12)	GAD = 4:8 HC not given	Mean for both = 37.6	Not reported	Not reported
Mathews & MacLeod, 1985	GAD Patient (no information reported) (n = 24) vs HC (n = 24)	GAD = 12:12; HC = 12:12	GAD = 33.3; HC = 31.7	Not reported	Not reported
Mathews, May, Mogg, & Eysenck, 1990; Task 2	GAD Dx (n = 18) vs Recovered GAD (no Dx for at least 6 months; n = 18) vs HC (n = 18)	GAD = 6:12; Recovered = 9:9; HC = 8:10	GAD = 37.2 (11.7); Recovered = 40 (9.7); HC = 35 (11.3)	Not reported	Not reported
Mathews, Mogg, Kentish, & Eysenck, 1995	GAD Dx (n = 24) vs HC (n = 23)	GAD = 8:16; HC = 8:15	GAD = 34.6; HC = 37.5	Not reported	Not reported
Mogg, Mathews, & Weinman, 1989	GAD Patient (no information reported) (n = 18) vs HC (n = 18)	GAD = 2:16; HC = 5:13	GAD = 43.3 (27–63 years); HC = 36.5 (20–60 years)	Not reported	Not reported
Mogg, Mathews, Eysenck, & Mayo, 1991	GAD Dx (n = 12) vs HC (n = 12)	GAD = 6:6; HC = 3:9	GAD = 37.8; HC = 35.8	Not reported	Not reported

Table 1 (*continued*)

Study	Sample	M:F ratio	Age range mean (SD)	Ethnicity	Comorbidity
Mogg, Mathews, & Eysenck, 1992	GAD Dx (n = 18) vs Recovered GAD (no dx for at least 6 months; n = 18) vs HC (n = 18)	GAD = 6:12; Recovered = 9:9; HC = 8:10	GAD = 37.2; Recovered = 40; HC = 35	Not reported	Not reported
Mogg et al., 1993	GAD Dx (Intvw; no dep) & > 10 on HADS-A (n = 19) vs Dep Dx & > 12 HADS-D (n = 18) vs HC (HADS-A < 11, HADS-D < 13; n = 18)	GAD = 5:14; Dep = 4:14; HC = 8:10	GAD = 38.2; Dep = 34.8; HC = 39.1	Not reported	Not reported
Mogg, Bradley & Williams, 1995	GAD Dx (with no Dep) AND > 10 on HADS-A (n = 17) vs Dep Dx only (n = 17) vs HC with HADS < cut-offs (Anx and Dep) in study (n = 15)	GAD = 5:12; HC = 5:10; Dep = 5:12	GAD = 39.6; HC = 40.3; Dep = 34.5	Not reported	Not reported
Mogg, Bradley, Millar et al., 1995	GAD Dx (without Dep; n = 11) vs HC (n = 17)	GAD = 7:4; HC = 7:8	GAD = 37.8; HC = 32	Not reported	GAD: PD = 2; Social Phob = 1
Mogg, Millar, & Bradley, 2000	GAD Dx (without Dep) and > 10 on HADS-A (n = 14) vs Dep Dx and > 15 on BDI (n = 15) vs HC with < 8 on HADS-A and < 10 on BDI (n = 16)	GAD = 5:9; Dep = 3:12; HC = 9:7	GAD = 41.5 (16); Dep = 40.8 (12); HC = 36.7 (8.8)	Not reported	GAD: Social Phob = 1, PD = 3, Social Phob with PD = 1; Dep: GAD = 13, PD = 7, Agoraphobia = 5, Social Phob = 3, OCD = 1
Oathes et al., 2011	High Worry (PSWQ > 55; n = 17) vs Low Worry (PSWQ < 56; n = 11)	Worry = 4:13; Low worry = 5:6	Worry = 18.2 (0.42; 18–19); Low worry = 19.06 (1.00; 18–21)	High Worry = 13 White, 1 Asian, 1 Hispanic, 1 African American, 1 non-responded; HC = 10 White, 1 Hispanic	Not reported
Olatunji, Ciesielski, Armstrong, Zhao, & Zald, 2011	GAD Dx (n = 30) vs HC (n = 30)	GAD = 15:15; HC = 15:15	GAD = 38.63 (11.26); HC = 39.50 (10.29)	GAD = 86.7% 'Caucasian'; HC = 73.3% 'Caucasian'	Not reported
Rinck, Becker, Kellermann, & Roth, 2003; Exp 1	GAD Dx (n = 32) vs Speech Phob Dx (n = 29) vs HC (n = 31)	GAD = 56.6% male; Speech Phob = 60% male; HC = 56.7% male	GAD = 44.3 (9.8); Speech Phob = 46.2 (11.5); HC = 45.2 (12.1)	Not reported	Not reported
Rinck et al., 2003; Exp 2	GAD Dx (n = 26) vs HC (n = 26)	GAD = 0:26; HC = 0:26	GAD = 23.3 (5.3); HC = 22.6 (5.1)	Not reported	HC were allowed mild specific phob, but not specified
Sass et al., 2010	Anxious Apprehension (Worry) (> 62 on PSWQ AND < 50th percentile on MASQ; n = 21) vs Anxious Arousal (> 32 on MASQ AND < 50th percentile on PSWQ; n = 26) vs Low Anx (< 50th percentile on both PSWQ and MASQ; n = 36)	Worry = 5:16; Anx = 12:14; Low Anx = 20:16	Total Sample = 18.86 (0.87)	Total Sample = 81% European American; 13% Asian/Pacific Islander; 5% African American; 1% Hispanic	Not reported
Yiend et al., 2014; Exp 1	GAD Dx (SCID; n = 14) vs Anx (> 45 STAI-T; n = 14) vs HC (n = 14)	Not reported	GAD = 43.1 (7.1); Anx = 32.8 (8.6); HC = 45 (8.6)	Not reported	Not reported
Yiend et al., 2014; Exp 2	GAD Dx (SCID; n = 21) vs HC (n = 21)	Not reported	GAD = 40.48; HC = 38.62	Not reported	Not reported

Note. M:F = Male:Female; GAD = Generalized Anxiety Disorder; Dx = diagnosis; HC = healthy controls; PD = panic disorder; Phob = phobia; ADIS-R = Anxiety Disorder Interview Schedule – Revised; Dep = depression; PSWQ = Penn State Worry Questionnaire; Pers = persecutory; Anx = anxiety; SCAN-v10 = Schedules for Clinical Assessment in Neuropsychiatry – Version 10; STAI-T = State Trait Anxiety Inventory – Trait Scale; Exp = experiment; Intvw = clinical interview; HADS-A = Hospital Anxiety and Depression Scale – Anxiety; HADS-D = Hospital Anxiety and Depression Scale – Depression; BDI = Beck Depression Inventory; OCD = Obsessive Compulsive Disorder; SCID = Structured Clinical Interview for DSM Disorders; MASQ = Mood and Anxiety Symptom Questionnaire; MASQ-AD = Mood and Anxiety Symptom Questionnaire – Anhedonic Depression.

Table 2
Systematic review summary of attentional bias findings.

Study	G or W?	G/W grp size	Task	Stimuli	SOA (ms)	G/W bias vs HC?	G/W bias vs other grp (name of grp)?	Outcome	Additional attentional bias biological findings
Albu, 2008	G	20	Stroop	Words	n/a	Y	~	Reading Time	~
Ashwin et al., 2012	G	18	Visl. Search	Faces	300	Y	Y (Panic)	Mean RT	~
Becker et al., 2001	G	32	Stroop	Words	n/a	Y	Y (Sp Phob)	Reading Time	~
Blair et al., 2012	G	17	Stroop	Images	400	N	~	Mean RT	MPFC: GAD = HC; Amygdala: GAD < HC & SocP
Bradley et al., 1995	G	20	Stroop	Words	14 & u/r	Y	~	Mean RT	~
Bradley et al., 1995	G	11	Stroop	Words	14 & u/r	Y	Y (GAD + Dep)	Mean RT	~
Bradley et al., 1999	G	14	Attentional probe	Faces	500 & 1250	Y	~	Mean RT	~
Chen et al., 2013	G	42	Stroop	Words	1000	Y	N (Panic)	Mean RT	~
Dibartolo et al., 1997	G	15	Attentional probe	Words	2000	N	~	Mean RT	~
Engels et al., 2007	W	1	Stroop	Words	1500	N	N	Mean RT	Increased activation of ITG and hypoactivation in rACC in worriers v HC; worriers recorded more activation in left hemisphere IFG and ITG v anxious arousals (whom exhibited more right hemisphere activation); DLPFC used to direct attention away from positive words different to Broca's area used during periods of worry.
Freeman et al., 2000	G	12	Visl. Search	Images	10,000	N	N (Pers Delusions)	Eye Movement	~
MacLeod & Mathews, 1991	G	16	Attentional probe	Words	u/r	Y	~	Mean RT	~
MacLeod et al., 2007; Study 1	(G)	24	Attentional probe	Words	500	Y	~	Median RT	~
MacNamara & Hajcak, 2010	G	15	Attentional probe	Images	250	N	~	Mean RT	Larger LPP for aversive targets compared to neutral ones for all grps; LPP for aversive targets (compared to neutral) was bigger in GAD than HC when distractors were neutral.
Martin et al., 1991; Exp 2	G	12	Stroop	Words	n/a	~	Y (Trait Anx)	Reading Time	~
Martin et al., 1991; Exp 4	G	12	Stroop	Words	n/a	Y	~	Reading Time	~
Mathews & MacLeod, 1985	G	24	Stroop	Words	n/a	Y	~	Reading Time	~
Mathews et al., 1990; Task 2	G	18	Attentional probe	Words	u/r	Y	N (Recovered GAD)	Mean RT	~
Mathews et al., 1995	G	24	Attentional probe	Words	u/r	Y	~	Mean RT	~
Mathews et al., 1995	G	24	Stroop	Words	n/a	Y	~	Reading Time	~
Mogg et al., 1989	G	18	Stroop	Words	n/a	Y	~	Reading Time	~
Mogg et al., 1991	G	12	Attentional probe	Words	u/r	Y	~	Mean RT	~
Mogg et al., 1992	G	18	Attentional probe	Words	500	Y	N (Recovered GAD)	Mean RT	~
Mogg et al., 1993	G	19	Stroop	Words	14 & u/r	Y	Y (Dep)	Mean RT	~
Mogg, Bradley and Williams, 1995	G	17	Attentional probe	Words	14 & 1000	Y	~	Mean RT	~
Mogg, Bradley and Williams, 1995	G	17	Attentional probe	Words	14 & 1000	~	N (Dep)	Mean RT	~
Mogg, Bradley, Millar et al., 1995	G	11	Stroop	Words	14 & u/r	Y	~	Mean RT	~
Mogg et al., 2000	G	14	Attentional probe	Faces	1000	N	N (Dep)	Mean RT	~
Mogg et al., 2000	G	14	Attentional probe	Faces	1000	Y	Y (Dep)	Eye Movement	~
Oathes et al., 2011	W	17	Stroop	Images	6000	N	~	Mean RT	Worriers had reduced pupil dilation v HC on incongruent Stroop trials; for negative personally-relevant words: low worriers had greater sustained pupil reactivity v worriers; there were no grp diffs specific to threat words
Oathes et al., 2011	W	17	Stroop	Words	6000	Y	~	Mean RT	~
Olatunji et al., 2011	G	30	Attl. Blink	Images	100	N	~	Response Accuracy	~

Table 2 (continued)

Study	G or W?	G/W grp size	Task	Stimuli	SOA (ms)	G/W bias vs HC?	G/W bias vs other grp (name of grp)?	Outcome	Additional attentional bias biological findings
Rinck et al., 2003; Exp 1	G	32	Visl. Search	Words	u/r	Y	Y (Sp Phob)	Mean RT	~
Rinck et al., 2003; Exp 2	G	26	Visl. Search	Words	u/r	Y	~	Mean RT	~
Sass et al., 2010	W	21	Stroop	Words	1500	N	~	Mean RT	Worriers prioritised processing of emotional words; anxious arousals process even earlier; no grp diffs at later (> 300 ms) processing
Yiend et al., 2014; Exp 1	G	14	Sptl Cueing	Faces	u/r	Y	N (Trait Anx)	Mean RT	~
Yiend et al., 2014; Exp 2	G	21	Sptl Cueing	Faces	200 & 500	N	~	Mean RT	~
Yiend et al., 2014; Exp 2	G	21	Sptl Cueing	Faces	300 & 700	N	~	Mean RT	~

Note. Some studies have more than one row where analyses were conducted separately or where different findings were reported for separate comparisons; GAD = Generalized Anxiety Disorder; G = GAD; W = high worry; Grp = group; SOA = stimulus onset asynchrony; ms = milliseconds; HC = healthy controls; n/a = not applicable; ~ = not assessed; Visl = visual; Y = yes; N = no; RT = reaction time; Sp Phob = speech phobia; SocP = social phobia; u/r = until response; Dep = depression; Anx = anxiety; Pers = persecutory; Sptl = spatial; MPFC = medial prefrontal cortex; IFG = inferior frontal gyrus; ITG = inferior temporal gyrus; DLPFC = dorsolateral prefrontal cortex; rACC = rostral anterior cingulate cortex; LPP = late positive potential.

male participants, ranging from 0% to 75% male participants. Only four studies provided information about participant ethnicity. In total, GAD/worry participants comprised a predominantly 'White/Caucasian' ethnic bias (78% 'White/Caucasian'), whilst healthy control comparisons comprised 81% 'White/Caucasian'. One study only reported ethnicity for the whole sample, with 81% of their sample being 'European American' (Sass et al., 2010).

3.2. Study designs

Fifteen studies used a form of the affective Stroop Task, 11 studies used a form of the attentional probe task, five used a visual search paradigm, one study used an attentional blink paradigm and two studies used variants of the spatial cueing task. All studies used visual stimuli in the paradigms, although the type of visual stimuli used in the studies varied somewhat. The stimuli valence also varied with studies comparing threat material with either one or more differently-valenced material. Ten studies compared threat/negative/anxiety/GAD-related stimuli with neutral stimuli only (Albu, 2008; Dibartolo et al., 1997; MacLeod & Mathews, 1991; MacLeod et al., 2007; MacNamara & Hajcak, 2010; Martin et al., 1991, experiment 2; Mathews & MacLeod, 1985; Mogg et al., 1992; Mogg et al., 1991, 1989); and eighteen studies compared threat with positive stimuli (Ashwin et al., 2012; Becker et al., 2001; Blair et al., 2012; Bradley et al., 1999; Chen et al., 2013; Engels et al., 2007; Freeman et al., 2000; Martin et al., 1991, experiment 4; Mathews et al., 1990, task 2; 1995; Mogg, Bradley & Williams, 1995; Mogg et al., 1993, 2000; Oathes et al., 2011; Rinck et al., 2003, experiment 2; Sass et al., 2010; Yiend et al., 2014, experiment 1). Several studies examined the specificity of the bias to threat by comparing threat/GAD-related stimuli with sad/depression stimuli (n = 5; Bradley et al., 1995; Mogg, Bradley, Millar et al., 1995; Mogg et al., 1993, 2000; Mogg, Bradley & Williams, 1995), anxiety disorder specific stimuli (speech phobia, Becker et al., 2001; Rinck et al., 2003, experiment 1); (panic disorder, Chen et al., 2013), or other stimuli related to disgust or eroticism (Olatunji et al., 2011), or by comparing physical threat with social threat stimuli (Martin et al., 1991, experiment 2, experiment 4; Mathews & MacLeod, 1985; Mathews et al., 1990, task 2, 1995; Mogg et al., 1992, 1989) or by comparing potential threat with direct threat and hidden threat (Freeman et al., 2000).

There was a variety of exposure times used among the sample of papers, as can be seen in Table 2. Four studies included masked stimuli to ensure they were presented outside of conscious awareness (Bradley et al., 1995; Mogg, Bradley, Millar et al., 1995; Mogg, Bradley & Williams, 1995; Mogg et al., 1993), whilst 16 studies had designs where the stimuli were presented until the participant made a response, or where stimulus duration was present throughout the task (e.g., colour-naming words presented on a card for the affective Stroop task).

3.3. Overall study findings

3.3.1. Do adults with GAD/high worry attend more to threat compared to healthy controls?

Attentional bias to threat among adults with GAD/worry compared to healthy controls was found in 22 out of 32 studies (69%). All these studies supported the hypothesis that GAD/worry participants attend more to threat than healthy controls, with all but one of them using speed of responding (e.g., reaction time, reading time, or eye movement data) as the primary outcome variable. When accuracy was used as an outcome variable (n = 15 studies), only MacNamara and Hajcak (2010) reported a bias among GAD compared to healthy controls, and this was only when threat stimuli were used as distractors and not as the target stimuli.

As described earlier, only three studies used a non-clinical group of worriers as their population of interest. Of these studies, Engels et al.

(2007) and Sass et al. (2010) found no attentional bias to threat among worriers compared to healthy controls. Oathes et al. (2011) also found no difference between worriers and healthy controls when images were used as the stimulus, but did find bias to threat among worriers compared to healthy controls when they used words as the experimental stimulus. MacLeod et al. (2007) also found a similar significant difference using words in their experiment comparing healthy controls with a sample of GAD participants who had been recruited through a self-report diagnostic questionnaire (and therefore lacks confirmation that the 'GAD' group were of clinical severity).

One important factor to consider when examining bias among anxious populations compared to healthy controls is level of depression (Bar-Haim et al., 2007). Only nine studies actively controlled for depression in their design or through their analysis (Albu, 2008; Becker et al., 2001; Bradley et al., 1995, 1999; Engels et al., 2007; Martin et al., 1991, experiment 2; Mogg, Bradley & Williams, 1995; Mogg et al., 2000; Sass et al., 2010). Of these nine studies, five (Albu, 2008; Bradley et al., 1995; Mogg, Bradley & Williams, 1995; Rinck et al., 2003) reported significant bias to threat among GAD/worry compared to healthy controls, whilst Engels et al. (2007), Mogg et al. (2000) and Sass et al. (2010) failed to find a group difference between GAD/worry and healthy controls. There were sixteen studies that had reported group differences in depression (and one study without a measure of depression; MacLeod et al., 2007) and all reported a significant bias to threat among GAD/worry participants compared to healthy controls without controlling for these differences in depression.

3.3.2. Does this attentional bias to threat among GAD/worry groups differ from other clinical groups?

GAD participants' attentional bias was compared to other clinical populations of speech phobia patients, panic disorder patients, individuals with depression, and individuals with persecutory delusions. There were also comparisons with GAD groups and recovered GAD patients and those with trait anxiety. The results appear largely inconclusive, with seven studies finding a significant bias to threat in the GAD group compared to the comparison group, whilst six studies reported no group differences. Any overall conclusions must be qualified by different comparisons producing slightly different results. For example, Rinck et al. (2003) found a bias to threat to be specific to distractibility of GAD words (and not speech phobia-related words) and they also reported no attentional bias to any type of threat words among speech phobia patients. Becker et al. (2001) found this attentional bias among GAD patients to be general (biased to GAD-related words and speech phobia-related words equally), whilst speech phobia patients reported a specific bias to speech phobia-related words only (GAD and speech phobia groups did not differ in speech phobia-related words' latencies).

One study found GAD participants to be significantly more biased to threat compared to panic disorder patients (Ashwin et al., 2012) but only when the threat was paired with neutral distractors, whilst the panic disorder patients reported a greater bias to threat than GAD patients when threat was paired with emotional (happy) distractors. Chen et al. (2013) found no difference between these two clinical populations overall (Chen et al., 2013), but they did report within-group analyses that showed that GAD participants were more biased to both GAD and panic-related words (compared to neutral and positive words), whilst the panic disorder patients only displayed a specific bias to panic disorder-related words (and not GAD-related words as well).

Mogg, Bradley and Williams (1995) found GAD participants were not more biased in terms of attention to threat (anxiety-related or depression-related words) than depressed participants using behavioural reaction time data (although they did find that depressed patients were biased to anxious words only at supraliminal exposure durations compared to GAD participants). Mogg et al. (2000) also found no significant attentional biases in either GAD or depressed patients using behavioural data. In contrast, Mogg et al. (1993) found a greater bias to

threat in GAD than depressed individuals using similar behavioural data and this bias was regardless of whether the stimuli were anxiety-related or depression-related words. Mogg et al. (2000) found a significant bias to threat among GAD participants when compared to depressed participants using eye movement data only, but this bias was specific to angry faces (threat) only and not sad faces as well. Bradley et al. (1995) sub-divided their sample of GAD participants into those with comorbid depression and those with GAD only and found that the GAD only participants had a significant attentional bias to threat compared to those with comorbid depression, and this was specific to anxiety-related words and not depression-related words as well.

Neither Mathews et al. (1990, task 2) nor Mogg et al. (1992) found any significant difference between GAD participants and recovered GAD patients on current attentional bias to threat, with both studies also reporting that neither GAD nor recovered GAD groups found any difference in RTs for physical versus social threat. Freeman et al. (2000) reported that GAD participants were not significantly different to individuals with persecutory delusions on any attentional bias to direct, hidden, or potential threat. Finally, Engels et al. (2007) and Sass et al. (2010) both failed to find any bias to threat when comparing their trait worry group with a trait anxious group.

3.3.3. Is attentional bias to threat among GAD/worry groups found across all experimental paradigms?

Attentional bias to threat was found in the majority of experimental paradigms identified in this review. Eight out of the eleven studies (73%) using the attentional probe task found a bias to threat among GAD participants compared to healthy controls, with only Dibartolo et al. (1997), MacNamara and Hajcak (2010), and Mogg et al. (2000) failing to find a group difference. Of note, though, Mogg et al. (2000) found a bias among GAD participants compared to healthy controls when using eye movement data in their attentional probe task (rather than the behavioural reaction time data used by all the other studies adopting the attentional probe task). These eye movement data were also the only finding of a group difference between GAD and another clinical/anxious group using the attentional probe task (four other studies failed to find a group difference between GAD and either recovered GAD patients or depressed patients), suggesting that GAD were biased to threat compared to depressed patients.

Twelve out of fourteen studies (86%) that used the affective Stroop task found GAD/worry participants to have attentional bias to threat compared to healthy controls. Only four studies failed to find a group difference with GAD/worry participants and healthy controls using the affective Stroop task. Four out of five studies using the affective Stroop task found a bias to threat among GAD compared to other clinical/anxious groups, with only Chen et al. (2013) failing to find a group difference (between GAD and panic disorder).

Three out of four studies that used a visual search task found attentional bias to threat among GAD compared to healthy controls, and two out of three visual search studies found a bias to threat among GAD compared to other clinical populations (panic disorder and speech phobia). Neither the attentional blink task used by Olatunji et al. (2011), nor the spatial cueing tasks used by Yiend et al. (2014, experiment 2) found GAD participants to be more biased to threat compared to healthy controls. Yiend et al. (2014, experiment 1) also found no bias to threat among GAD participants compared with a matched non-clinical group of trait anxious individuals. Interestingly, Yiend et al. (2014, experiment 1) did find that within GAD participants only, there was speeded disengagement from threat, suggesting an opposite bias to that expected, implying that GAD participants were biased away from threat and thereby indicating possible attentional avoidance.

Some of the lack of findings found in the above tasks may have been due to specific aspects of the methodological designs. These key aspects are reported below.

3.3.4. Is attentional bias to threat among GAD/worry groups found at different stimuli exposure times?

The studies reviewed here adopted a variety of stimulus exposures across various experimental tasks. Four studies directly compared subliminal exposures (14 ms, masked) with supraliminal exposures (1000 ms or until participant responded). All of these studies found no significant finding of exposure duration, indicating that attentional bias to threat that they found in GAD participants compared to healthy controls occurred regardless of subliminal or supraliminal conditions. This suggests that bias may not always be determined solely by bottom-up or top-down processes, but by either one (although it cannot be ruled out that the biases seen in the longer SOAs were still due to persisting effects of bottom-up processes). However, other analysis carried out by Bradley et al. (1995) found that GAD participants were biased to threat compared to healthy controls only in the condition where the word stimuli were on screen until participants made a response, with no group difference occurring at the 14 ms SOA condition.

Yiend et al. (2014, experiment 2) also used two, SOA conditions that included shorter SOAs, comparing 200 ms vs 500 ms and 300 ms vs 700 ms, and their study found no significant bias to threat among GAD compared to healthy controls, regardless of SOA condition. This may have been due to the method (spatial cueing task) or to the chosen stimuli (faces; see below). One significant finding reported in this particular study was that there was a general slowing of reaction times in response to fearful compared to neutral cues and this only occurred at 700 ms and not 300 ms. This general slowing though was not specific to GAD participants.

Four other studies used SOAs of < 500 ms and as such could be regarded as testing more automatic attentional bias mediated by bottom-up processes. In these studies, only Ashwin et al. (2012) found a significant bias to threat among GAD participants compared to healthy controls, implying minimal evidence for bottom-up processes being involved in attentional bias among GAD individuals. However, the other three studies had all used images for their experimental stimuli and this may have contributed to a lack of significant findings (see below) rather than the exposure durations.

Studies in which SOAs were around 500 ms, when both bottom-up and top-down processes may operate, all found GAD/worry participants biased to threat compared to healthy controls. Bradley et al. (1995) compared an SOA of 500 ms with 1250 ms and found the bias was present regardless of exposure condition. The other studies, in which stimuli were presented for 1000 ms or longer produced, equivocal results. Two out of three findings for SOAs of 1000 ms showed a significant bias to threat to threat among GAD participants compared to healthy controls, whilst among the six studies that stipulated a stimulus exposure of 1500 ms or greater, only Oathes et al. (2011) found a significant bias to threat among their high worriers compared to non-worriers, and this was only for words and not images. Interestingly, in all studies in which stimuli were exposed until participants responded, or in the affective Stroop design where stimuli were permanently present until the participant finished reading all words, a significant bias to threat was found among GAD versus healthy controls. Once again, it is unclear whether extended exposure time is a potential factor that could be influencing the bias within GAD participants, or whether it was due to the fact that the overwhelming majority of these types of studies also used words as the type of stimulus, thus enhancing the chances of finding bias differences (see below).

3.3.5. Is this attentional bias to threat among GAD/worry groups found with all types of stimuli?

3.3.5.1. Verbal-linguistic stimuli (words) vs. image-based stimuli (pictures/faces). All studies adopted visual stimuli; however, the form of these visual stimuli varied between words, faces, and pictures (e.g. of scenes), and these differences appear to have led to different results between studies. Of the eleven studies that found no attentional bias to threat among GAD/worry participants compared to healthy controls, eight of them had used either pictures of scenes or faces. Contrastingly, of the 25 studies that identified attentional bias to threat among GAD/worry groups compared with healthy controls, only four used faces and none had used pictures. Put another way, no study that used pictures as experimental stimuli found attentional bias to threat among GAD/worry compared to either healthy controls or any other clinical population (although only a comparison with individuals with persecutory delusions was made). Facial stimuli studies only found a group difference in attentional bias between GAD/worry participants and healthy controls in four out of seven studies. Further, one of these significant findings with facial stimuli found that GAD were biased *away* from threat (Yiend et al., 2014, experiment 1), which is in the opposite direction to that expected based on the other review findings. Contrastingly, of the 24 findings using word stimuli across several experimental paradigms, 21 found a significant attentional bias to threat among GAD/worry participants compared to healthy controls. Of the three studies that failed to produce a significant group finding, Engels et al. (2007) and Sass et al. (2010) had used a non-clinical trait worry group, whilst Dibartolo et al.'s (1997) threatening stimulus was the word "miss" and so was an atypical method for assessing attention to threat. Both of these factors may have contributed to a lack of finding in these three studies.

In addition to comparison with healthy controls, experimental studies that used word stimuli also found that GAD participants were significantly biased to threat compared to depressed individuals, speech phobic individuals, and trait anxious individuals. Only Mogg, Bradley and Williams (1995; vs depression) and Chen et al. (2013; vs panic) failed to find a difference between GAD and a different clinical population when using word stimuli. Interestingly, Mathews et al. (1990, task 2) and Mogg et al. (1992) found no difference between GAD and recovered GAD patients, suggesting that attentional bias to threatening word stimuli continues even after successful treatment for the anxiety disorder.

3.3.5.2. Effects of emotional valence. Of the 20 studies that included another valence in their analyses (predominantly positive), only four found support for the general emotionality hypothesis. In other words, in these studies the GAD/worry participants were biased to both threat *and* positive stimuli equally (no significant difference between stimuli) compared to neutral stimuli in comparison with healthy controls (Ashwin et al., 2012; Becker et al., 2001; Bradley et al., 1999; Martin et al., 1991, experiment 4). Further, the Bradley et al. (1999) finding was only for the first half of the trials, after which a specific bias to threat (and not to positive as well) was found among GAD participants compared to healthy controls. Only Olatunji et al. (2011) compared threat with emotions other than positive/happy valence, namely examining disgust and erotic stimuli. They found no bias in their GAD participants compared to healthy controls across any stimuli valence.

3.3.5.3. Type of threat. Finally, in terms of the specificity of the *type* of threat, seventeen studies conducted threat type analyses, comparing either physical threat with social threat (Martin et al., 1991, experiment 2, experiment 4; Mathews & MacLeod, 1985; Mathews et al., 1990, 1995; Mogg et al., 1992, 1989), potential, hidden and direct threat (Freeman et al., 2000), or GAD/anxiety-related stimuli with speech phobia-related stimuli (Becker et al., 2001; Rinck et al., 2003, experiment 1), with panic disorder stimuli (Chen et al., 2013), or with sad/depression-related stimuli (Bradley et al., 1999; Mogg, Bradley, Millar et al., 1995; Mogg, Bradley & Williams, 1995; Mogg et al., 1993, 2000). No study found evidence of a bias difference between physical and social threat. However, two additional studies sub-divided their GAD sample into those with primarily physical worries and those with primarily social worries and found that threat was specific to primary worry (Mogg et al., 1989), although this only

occurred if participants reported their primary worry as being physical worries, with social worries being biased across all GAD participants (Mathews & MacLeod, 1985). In comparison with depression words, only Bradley et al. (1995) found a specific threat to anxiety words rather than depression words as well (although this was only at the supraliminal condition) and Mogg et al. (2000) found a specific bias of GAD rather than sad words (in eye movement data only), whilst all other studies found GAD words and depression words were equally biased among GAD participants when compared to healthy controls. Rinck et al. (2003, experiment 1) found there to be a specific bias to GAD-related threat rather than speech phobia-related stimuli as well, whilst Becker et al. (2001) found no difference in bias between GAD-related stimuli and speech phobia-related stimuli, and Chen et al. (2013) found no difference between GAD-related and panic disorder-related stimuli. Finally, Freeman et al. (2000) reported no bias to threat (regardless of type of threat). Overall, therefore, 11 out of 17 studies reported that the bias was of a general nature and not specific to GAD-related stimuli, whilst only three studies reported the bias to be specific to GAD-related stimuli compared with other threat/anxiety disorder stimuli.

3.4. Quality of studies

The quality assessment found that the majority of studies were of acceptable quality (*n* = 24), with a further five studies being rated as 'good quality' (Becker et al., 2001; Blair et al., 2012; Bradley et al., 1995; Mogg et al., 1993, 2000). The 'good quality' studies were rated as such due to their attention to controlling for all of the key confounders of age, gender, IQ/verbal ability, and depression, as well as reporting a low level of risk of other potential biases (i.e., selection bias, information bias, performance bias, or attrition bias). A significant threat bias in GAD/worry participants compared to healthy controls was reported in four out of the five 'good quality' studies.

Only four studies were categorised as 'low quality' (MacLeod et al., 2007; MacNamara & Hajcak, 2010; Mathews & MacLeod, 1985; Yiend et al., 2014, experiment 2), with two finding a significant bias to threat compared to healthy controls and two studies reporting no significant threat bias. The reasons for these studies being of 'low quality' were in part due to potential selection bias risk. MacLeod et al. (2007) lacked any controlling of important confounding variables of age, gender, IQ, and depression. The same study also demonstrated an increased risk of information bias as the diagnosis of GAD to form group entry was done via an online self-report questionnaire, rather than a recognised clinical interview and thus it lacked suitable known validity and/or reliability. MacNamara and Hajcak's (2010) study had also not controlled for the important factors of age and gender in their comparison of a worry group versus a control group and thus demonstrated potential selection bias risk, whilst Yiend et al. (2014, experiment 2) had not reported controlling for gender, IQ, or depression. Mathews and MacLeod's (1985) study was categorised as 'poor quality' as minimal information was given about the diagnostic confirmation of the GAD group and the 'control' group were also reported to have a degree of overlap in terms of level of trait anxiety, therefore making results more difficult to interpret.

4. Discussion

The current systematic review examined the empirical evidence of attentional bias to threat in those with a diagnosis of GAD and high trait worriers (without GAD), compared to healthy controls and other clinical populations. The key conclusion is that there is evidence within the studies reviewed here to suggest that individuals with a clinical diagnosis of GAD show attentional bias favouring threatening information relative to non-clinical populations, as this evidence was found in over two-thirds of the studies included in the review. However, there was a relative paucity of studies that had investigated high worriers

without GAD and it is recommended that more research should address this issue in such clinically-vulnerable individuals.

The finding of attentional bias to threat among GAD patients fits with previous reviews that had suggested that such biases are common among anxious populations (Bar-Haim et al., 2007; Mogg & Bradley, 2005). The present review has updated these findings by systematically identifying this bias within the specific diagnosis of GAD. Other studies have also identified attentional bias to threat in non-clinical trait anxious individuals and it was hoped that this could be replicated in high trait worry. However, only three studies satisfied the inclusion criteria for the current review. Oathes et al. (2011) used high worriers and found attentional bias to threat compared to low worriers when using words as stimuli, but not when using pictures; whilst Engels et al. (2007) and Sass et al. (2010) did not find a selective attention to threat words in a high worry group compared to healthy controls. These conflicting results and the fact that there is evidence from only three studies highlights the need for further research of attentional biases in non-clinical but high trait worriers. Indeed, Ruscio (2002) highlight the various similarities and differences between GAD individuals and those with high levels of worry but without a GAD diagnosis. This line of enquiry is called for in general, but relevant to the current review is the recommendation for further research focusing specifically on attentional bias to threat in high worriers and examining the relevant distinctions between them and clinical GAD populations.

Though worriers may fear experiencing a range of different emotions, including positive ones (Turk, Heimberg, Luterek, Mennin, & Fresco, 2005), the overall evidence found in the studies reviewed here was that the attentional bias to threat among GAD participants was specific to negative threatening material compared to other types of valenced material, such as positive valence. These findings therefore support the view of there being a specific threat detection process (Beck et al., 1985) and/or evaluation system as outlined by such theoretical models as Mathews and Mackintosh's (1998) selective processing in anxiety model and Williams, Watts, MacLeod, and Mathews' (1988) model. These early systems are designed to evaluate affective meaning and significance at an early stage of processing, focusing on 'tagging' threatening stimuli, rather than a general system that gets activated by any (i.e., including positive) emotionally arousing material and resulting in prioritised processing.

In keeping with the diagnosis of GAD, where worry is evident across domains, attention bias in GAD tends to also be evident across a range of domains. This is in contrast to other anxiety disorders where fear content is confined to one domain that is specifically related to their disorder. For example, Becker et al. (2001) found that whilst their speech phobia sample was only biased to speech phobia-related words, their GAD sample was biased to both GAD-related words as well as speech phobia-related words. Likewise, Chen et al. (2013) found that GAD participants were biased to GAD and panic disorder-related stimuli, whilst the panic disorder patients only reported bias to panic disorder-related stimuli. It is important to examine the disorder-specificity of material as it is believed that the more specific the biases (i.e., social material for social anxiety disorder patients) the more causal effect the biases will have on the disorder (Yiend, 2010). However, in contrast, the collective findings here could suggest that worriers may be vulnerable to developing a range of anxiety disorders given their non-domain specific focus of attentional bias in this population. Importantly, though, as alluded to in the introduction, the association between attentional bias to threat and anxiety or worry is likely to be more complicated than a simple unidirectional cause and consequence relationship (Van Bockstaele et al., 2014). As such, further specific research needs to be conducted to examine the intricacies and temporal precedence of attentional bias to threat and worry.

Attentional bias to threat found in this review was demonstrated across the major experimental paradigms and builds upon other research that has highlighted attentional biases to threatening stimuli

among anxious individuals when using the affective Stroop task (e.g., Owens, Asmundson, Hadjistavropoulos, & Owens, 2004), the attentional probe task (e.g., Broadbent & Broadbent, 1988), and spatial cueing tasks (e.g., Fox et al., 2001; Yiend & Mathews, 2001). This review also demonstrated moderate evidence for attentional bias to threat using visual search paradigms (Ashwin et al., 2012; Rinck et al., 2003). Of more interest were the findings of some specific design variations used within the paradigms, which appeared to have more of an effect on attentional bias findings than the overall choice of paradigm itself. This was seen most clearly in studies which had used verbal-linguistic visual stimuli (i.e., words; e.g., Bradley et al., 1995) versus those studies which had used pictorial stimuli (i.e., pictures of scenes and faces; e.g., Blair et al., 2012).

4.1. Verbal vs pictorial processing

There was overwhelming evidence found in the current review that attentional bias to threat among GAD participants compared to healthy individuals is more likely to be observed when using words than when using picture stimuli. Among studies that used words as the stimuli, over 75% of them found a significant bias effect in GAD/worry participants compared to other groups, whilst there was no evidence in the current review showing that GAD participants are more biased to threatening *pictures* than healthy controls. There was only weak to moderate evidence that this comparative bias to threat exists for stimuli that were faces. This may fit with the wider literature on worry that demonstrates that mental-imagery (that includes a visual modality) is infrequent and brief during worry (Hirsch et al., 2012), supporting the idea that worry is a verbal rather than imagery-based process (Leigh & Hirsch, 2011; Stokes & Hirsch, 2010; Williams et al., 2014). In fact, the very form of worry itself may further contribute to attentional bias to threat. For example, Williams et al. (2014) instructed their high worriers to worry either verbally ("to think in words, sentences and questions about the negative aspects of four scenarios", p.10) or in mental-imagery ("consider a feared outcome… imagine yourself in a time- and location-specific manner, as though it were happening now", p.10). They found that those who had worried in words and sentences had a significant bias to threat words in a subsequent attentional probe task, whilst those who had worried in mental-imagery did not. These experimental studies demonstrate the importance of the verbal-linguistic style of processing in worry on attentional bias to threat. This verbal-linguistic processing may also lead directly to negative thought intrusions in worriers. For example, Stokes and Hirsch (2010) trained a group of high worriers to worry in either verbal or mental-imagery format (using similar instructions to Williams et al.'s (2014) study) and found that those who had worried in verbal format reported an increase in subsequent negative intrusions (contrastingly they also found that those who had engaged in mental-imagery based worry actually reported a decrease in negative intrusions). Overall, then, this prior research highlights the influence of negative verbal-linguistic processing on attentional bias to threat and also in directly maintaining negative intrusions in worriers.

It also therefore fits with the findings of the current review of attentional bias to threat effects among GAD/worry participants being more established using verbal-linguistic stimuli than pictorial stimuli. A reason for the negative effects of verbal versus mental-imagery based worrying could be due to the former leading to a relatively greater reduction in working memory capacity, as was found by Leigh and Hirsch (2011) among their sample of worriers (but not low worriers), which may reduce attentional control resources (Klein & Boals, 2001). This fits with neural research into attentional bias among worriers. In particular, Engels et al. (2007) compared worriers' ('anxious apprehensive' individuals) performance on an Affective Stroop task to 'anxious arousal' individuals (high physiological anxiety, with limited worry) and healthy controls. Their findings highlighted that worriers reported significantly greater left hemisphere brain activity (around the lan-

guage-processing centre of Broca's area) in response to threatening stimuli compared to trait anxious individuals who reported greater right-hemisphere activity. They noted that "worry may affect attention and working memory by drawing on a limited pool of resources" (p. 360), leading to poorer performance on the task at hand (i.e. colour naming). Thus, it would appear that continuous worry 'rehearsal' among trait worriers can lead to difficulty in focusing on, or redirecting attention to, non-worry based content.

4.2. Engagement vs disengagement

The distinction between biased engagement and difficulty in disengagement has been a key focus of previous studies and reviews (Cisler & Koster, 2010; Cisler et al., 2009; Clarke et al., 2013) and this distinction, arguably, can be inferred by findings at different stimulus exposure durations. The current review found that GAD/worry participants showed biases to threat at both short duration exposure times suggestive of biased engagement to threat using subliminal processing (e.g., Mogg, Bradley, Millar et al., 1995), as well as in exposure durations of > 1000 ms (e.g., Oathes et al., 2011) indicative of delayed disengagement. Further, there was minimal evidence that GAD/worry participants were biased *away* from threat at medium to long exposure durations, thereby demonstrating little support for the vigilance-avoidance hypothesis of attentional bias to threat (Mogg & Bradley, 1998). Only one study found a bias away from threat, suggesting an avoidance of threat rather than of difficulty disengaging from threat (Yiend et al., 2014, experiment 1) when the disengage mechanism is specifically assessed. Several other studies found no significant attentional biases to threat among GAD/worry participants using behavioural outcomes at supraliminal exposure durations (Dibartolo et al., 1997; Engels et al., 2007; Freeman et al., 2000; Sass et al., 2010) (although it is important to note that biological outcomes can differ, for example Sass et al., 2010 found evidence of prioritization (N200 amplitude) of both pleasant and threat stimuli, at around 200 ms exposure, that did not translate into reaction time effects). These null findings may have been due to greater individual differences in attentional control strategies and abilities. In other words, without controlling for such potential confounding variables as attentional control ability, null findings may occur as it has been shown that biases only occur in those with both high levels of trait anxiety *and* poor attentional control abilities (Derryberry & Reed, 2002). Therefore, this may be the case in GAD/worry participants as well, although this suggestion requires further research.

Instead of the vigilance-avoidance hypothesis being true of GAD/worry participants, these current review findings could infer that GAD/worry participants are more likely to have difficulty disengaging from the threat as demonstrated by their biases to threat at more prolonged exposure durations (e.g., at 6000 ms; Oathes et al., 2011) or when stimuli were present until a response was made (e.g., Mathews et al., 1995). However, Clarke et al. (2013) argued that the attentional probe task, similar to the Stroop task, is unable to fully disentangle the effects of biased engagement and difficulty in disengagement without first employing necessary design criteria proposed by them, which many of the current studies did not fulfil. Therefore, although it has been postulated that there is delayed disengagement from threat among worriers (Hirsch & Mathews, 2012), which is partly supported in the current papers reviewed here, it cannot be concluded that the attentional bias to threat found among GAD/worry participants is a result of difficulty in disengagement from threatening stimuli, as highlighted by Yiend et al. (2014). Future research needs to use adapted experimental methodology as outlined by Clarke and colleagues in order to fully understand the role of this aspect of attentional bias.

4.3. Bottom-up vs top-down processing

One aspect of the current findings that may also require further

investigation is the distinction between bottom-up and top-down processing of information. Several investigators have proposed that attentional processes involve initial bottom-up attentional capture, which is automatic and outside of awareness, as well as subsequent top-down attentional control, which is partly at a conscious level (Cisler & Koster, 2010). Blair et al. (2012) found that there was reduced top-down attentional control among individuals with GAD as a function of a reduced ability to recruit brain regions associated with this process, which was more impaired than among a comparative anxiety sample. This comparison between bottom-up and top-down processing can be approximately measured by examining findings at different stimulus exposure durations, with shorter SOAs assumed to measure more stimulus-driven attentional capture (bottom-up; in particular if presented subliminally) and longer SOAs (presented 'supraliminally') assumed to allow for the recruitment and increased influence of strategic attentional control (top-down). The studies in the current review that investigated purely subliminal processes (via the use of masked stimuli) compared to supraliminal processes predominantly found a bias to threat in both conditions. Despite this strong support for the bias to threat in GAD participants occurring at either subliminal or supraliminal exposure conditions and thereby suggesting a role for either bottom-up and/or top-down processes, one study failed to find a bias in their subliminal condition (Bradley et al., 1995). This finding implies that perhaps the bottom-up processes are not occurring in attentional bias to threat in individuals with GAD, which would fit with imaging research that has failed to find heightened amygdala sensitivity to threatening stimuli in adults with GAD (see Blair & Blair, 2012). In contrast however, there is evidence of extended amygdala activity in GAD (Paulesu et al., 2010) during worry. Furthermore, cognitive models of anxiety propose an automatic threat detection mechanism at the early stages of the attentional process (e.g., Beck & Clark, 1997), which would indicate the activation of amygdala pathways. However, unlike the majority of the other subliminal (14 ms, masked) studies, Bradley et al. (1995) had not controlled for concurrent depression in their GAD sample, and as such the lack of finding may have been due to a general slowing of response found among depressed individuals (White, Myerson, & Hale, 1997).

Distinguishing between bottom-up and top-down processes in relation to attentional bias may be challenging. Furthermore, Bargh (1989) categorised 'automatic' processing into preconscious, post-conscious and goal-dependent automaticity, where the latter two although being automatic, still require a degree of conscious processing. When presenting stimuli supraliminally therefore, it is currently still unknown whether the mechanisms for any identified biases are due to a single stage of Bargh's (1989) automaticity categorisation (or combination thereof). For example, Mogg, Bradley and Williams (1995) found a bias to threat subliminally but not so when stimuli were presented supraliminally and they concluded that the lack of significant findings supraliminally may be due to different processes occurring at different stages, and as such it makes interpretation difficult at these longer stimulus durations. Therefore, future work should look to examine the attention task performance under cognitive load (Cisler & Koster, 2010) and at a stimulus exposure duration sufficiently long enough to potentially involve all three of Bargh's (1989) stages of automaticity. If biases disappear under this additional cognitive load, and does not differ across manipulations of automaticity then it could help establish the role of conscious controlled processes in attention allocation.

4.4. Limitations

The current review had some limitations. First, the distinction between studies examining high/low worriers to the exclusion of high/low trait anxious populations may have led to many studies examining a bias to threat among individuals for whom worry is at a high level being excluded. However, this decision was taken to add

more specificity to the research question and target the at-risk group of individuals who suffer from the cognitive aspect of trait anxiety and not simply any person with high levels of trait anxiety (many of whom may or may not have high worry).

Methodologically, the review may have been limited by there being only a single reviewer and as such may be susceptible to subjective selection bias. To combat this limitation, any uncertainty on inclusion/exclusion of articles was discussed with a second reviewer and a consensus reached. Nonetheless, the lack of a second reviewer involved in the initial screening and selection of papers may unduly influence the results. Second, the quality of the studies were also only rated by the primary author and lacked double-rating using a second reviewer. This limitation was partly mitigated against by the use of a standardised quality assessment tool and the use of objective criteria in determining quality. A third limitation was the decision to review only published articles. This may have led to a publication bias with unpublished studies being excluded even though they may have provided useful (albeit non-significant) findings.

Finally, it was difficult to determine the exact processes underlying the findings in the majority of studies reviewed here, and thus limiting the strength of the conclusions being drawn. For example, the affective Stroop task was widely used in the reported studies but their findings are difficult to fully interpret, as it is difficult to establish whether this task assesses attentional bias or whether it is more accurately a measure of behavioural avoidance, and thus more closely aligned with attentional control, as De Ruiter and Brosschot (1994) found that both processes can contribute to differential findings among anxious individuals, but that it is the latter which appears to be more influential in affecting task performance. Further, when attentional bias has been identified by an empirical study using the affective Stroop task, it is invariably not clear whether the bias is due to engagement or disengagement difficulties. A recent study by Clarke, Hart and MacLeod (2014) has attempted to understand the attentional mechanisms associated with the affective Stroop task and concluded that bias effects are in fact more likely to be due to enhanced attentional engagement with the threatening stimuli rather than delayed disengagement from it. However, in contrast, Cisler and Koster's (2010) integrative review concluded that the attentional probe task more closely assessed a difficulty in disengaging from threat. Future research should look to further disentangle the components of attentional bias and its effects on anxiety symptoms, and in particular ensure that the methodological paradigms are adapted to reliably measure the distinct components of engagement and disengagement (Clarke et al., 2013).

5. Conclusions

In conclusion, this review updated the evidence of attentional processing biases to threatening stimuli among people with a clinical diagnosis of GAD and individuals with high levels of trait worry. Although there was a dearth of studies investigating non-diagnosed high worriers, the majority of studies found a significant attentional bias to threat among both GAD and high worry groups compared to healthy controls or other clinical/anxious samples. This positive finding was established across different experimental paradigms and was most comprehensively seen in studies that employed verbal-linguistic stimuli (words) rather than stimuli in pictorial form. Despite the positive findings in the majority of studies, there were still a sufficient number of non-significant findings to suggest that specific components and mechanisms of the bias require further investigation. This greater understanding of the key factors involved in attentional bias to threat among worriers may help develop and refine the latest treatments for GAD patients, such as attentional bias modification approaches.

Acknowledgments

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