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Content specificity of attention bias to threat in anxiety disorders: A meta-analysis

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HIGHLIGHTS

- This meta-analysis of 37 samples examines content specificity of attention bias.
- Results reveal a small but significant threat-bias specificity effect.
- The effect is discussed in relation to neuro-cognitive models of attention bias.
- The findings could bear implications for the design and stimulus choice in ABMT.
- Stimuli congruent with the anxiety disorder may produce better results.

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ABSTRACT

Despite the established evidence for threat-related attention bias in anxiety, the mechanisms underlying this bias remain unclear. One important unresolved question is whether disorder-congruent threats capture attention to a greater extent than do more general or disorder-incongruent threat stimuli. Evidence for attention bias specificity in anxiety would implicate involvement of previous learning and memory processes in threat-related attention bias, whereas lack of content specificity would point to perturbations in more generic attention processes. Enhanced clarity of mechanism could have clinical implications for the stimuli types used in Attention Bias Modification Treatments (ABMT). Content specificity of threat-related attention bias in anxiety and potential moderators of this effect were investigated. A systematic search identified 37 samples from 29 articles ($N = 866$). Relevant data were extracted based on specific coding rules, and *Cohen's d* effect size was used to estimate bias specificity effects. The results indicate greater attention bias toward disorder-congruent relative to disorder-incongruent threat stimuli ($d = 0.28, p < 0.0001$). This effect was not moderated by age, type of anxiety disorder, visual attention tasks, or type of disorder-incongruent stimuli. No evidence of publication bias was observed. Implications for threat bias in anxiety and ABMT are discussed.

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1. Introduction

Selective processing of threat has been studied widely and is thought to contribute to the etiology and maintenance of anxiety disorders. In particular, the tendency of anxious individuals to overly attend to threat stimuli has been documented with different attention tasks and in different types of anxiety (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). A causal relation between attention bias and anxiety has been demonstrated by experimentally inducing attention bias toward threat in healthy children and adults and recording associated elevations in stress reactivity (Eldar, Ricon, & Bar-Haim, 2008; Mathews & MacLeod, 2002). This research, underscoring the role of threat-related attention bias in anxiety has further informed the development of Attention Bias Modification Treatments (ABMT) designed to reduce anxiety through change in threat-related attention patterns (Bar-Haim, 2010; Mathews & MacLeod, 2002). Recent meta-analyses indicate that ABMT carries a significant small-to-medium effect size in anxiety reduction (Beard, Sawyer, & Hofmann, 2012; Hakamata et al., 2010; Hallion & Ruscio, 2011; Mogoase, David, & Koster, 2014).

Despite ample evidence for threat-related attention bias in anxiety, the underlying mechanisms supporting these biases remain largely unclear (Cisler & Koster, 2010; Heeren, De Raedt, Koster, & Philippot, 2013; Ouimet, Gawronski, & Dozois, 2009). One potentially relevant mechanistic aspect of threat-related attention bias in anxiety concerns the nature and the specific features of the threat stimuli that over capture the attention of anxious participants. Specifically, it is still unclear whether threat-related attention bias in anxiety is triggered by threats in general, regardless of their specific content, and thereby reflects perturbations in a generic neuro-behavioral mechanism, or alternatively evidenced exclusively, or more saliently, in relation to specific threat contents that are directly related to a participant's idiosyncratic angst.

Neuro-cognitive and cognitive models of anxiety emphasize different threat processing mechanisms that could contribute to threat-related attention bias and to the potential impact of threat's content on bias magnitude. For instance, some models emphasize the role of *threat detection* or *initial response to threat* as a major contributor to anxiety (Beck & Clark, 1997; Williams, Watts, MacLeod, & Mathews, 1988) This adaptive attentional function that facilitates detection of danger (LeDoux, 2000) is thought to be amplified in anxiety. In line with models emphasizing automatic capture of attention by minor threats in anxiety, amygdala hypersensitivity was shown among anxious but not healthy subjects, and the magnitude of amygdala engagement with threat stimuli positively correlated with both anxiety severity (Monk et al., 2008) and with attention bias toward threat (van den Heuvel et al., 2005). This view predicts initial, automatic threat evaluation, classifying incoming stimuli crudely as threatening or safe, without registering specific content (Mathews & Macleod, 1994). Such mechanism would allow relatively small impact for content specificity on threat-related attention bias in anxiety.

Other models refer to threat-related attention bias as a result of difficulty in regulation and allocation of attention (Bishop, 2007; Eysenck, Derakshan, Santos, & Calvo, 2007). For instance, it was found that anxious individuals showed poorer performance on attention control tasks with threat stimuli and less activation in the lateral pre-frontal cortex (LPFC) relative to non-anxious individuals (Bishop, Duncan, Brett, & Lawrence, 2004; Monk et al., 2006). The LPFC is thought to play a role in the regulation of amygdala activation in the presence of threat (Pine, Helfinstein, Bar-Haim, Nelson, & Fox, 2009; Quirk & Mueller, 2008). Emphasizing general attention control dysfunction as a primary mechanism underlying threat-related attention bias alludes to a more generic aspect of threat-related attention bias in anxious individuals that may be less affected by the specific content of threat.

Other models of threat processing describe a potentially more elaborate threat evaluation process that impacts attention allocation to threat (e.g., Bar-Haim et al., 2007; Beck & Clark, 1997; Mogg & Bradley, 1998; Öhman, 1996). These models assume schema-driven processing that rely on associations to personal learning and memory, that may involve a content-specific aspect of attention bias, driven by specific threats that are idiosyncratically relevant to a person's anxiety type.

The current meta-analysis investigates the potential role of content specificity in threat-related attention bias in anxiety against the backdrop of the alternative of more generic perturbations in attention allocation that leave much less room to content specificity. In addition to broadening the conceptualization of the nature of attention bias to threat in anxiety, the examination of *attention bias specificity* also carries potential clinical relevance for the development of treatments that rely on presentation of different threat-related stimuli.

Attention bias specificity has typically been explored by testing whether disorder-congruent stimuli (e.g., socially relevant stimuli for social phobia or trauma-related stimuli for posttraumatic stress disorder) render larger threat-related attention bias than do general threat stimuli, or stimuli that are congruent with the threat content of a different anxiety disorder (i.e., disorder-incongruent stimuli). Most studies compare the magnitude of threat-related attention bias of disorder-congruent and disorder-incongruent stimuli using response times in classic visual attention tasks. However, despite considerable research on stimulus specificity, results from single studies are mixed.

For example, Foa, Feske, Murdock, Kozak, and McCarthy (1991) found attention bias specificity for trauma-related words, relative to other threat-word types in rape-victims suffering from post-traumatic stress disorder (PTSD). Additional studies also reported content specificity effects in adults with PTSD (Ashley, Honzel, Larsen, Justus, & Swick, 2013; Buckley, Blanchard, & Hickling, 2002; Kaspi, McNally, & Amir, 1995; McNally et al., 1994), and in youth with PTSD (Moradi, Taghavi, Heshat Doost, Yule, & Dalgleish, 1999). Conversely, other studies did not find content specificity of attention bias in PTSD using trauma-related words either in adults (e.g., Litz et al., 1996) or children (Ribchester, Yule, & Duncan, 2010). Elsesser, Sartory, and Tackenberg (2004) did not find specificity effect with trauma-related pictures in PTSD patients, even when stimuli were selected idiosyncratically.

There is also accumulating data concerning specificity of threat attention bias in panic disorder, usually tested with words reflecting physical threats. Specificity was found in panic patients using both Stroop and dot-probe tasks (Asmundson, Sandler, Wilson, & Walker, 1992; Buckley et al., 2002, respectively). However, other studies did not find this effect neither in stroop (De Cort, Hermans, Spruyt, Griez, & Schruers, 2008; Gropalis, Bleichhardt, Hiller, & Witthöft, 2013; Kampman, Keijsers, Verbraak, Näring, & Hoogduin, 2002) nor in dot-probe tasks (Beck et al., 1992; Horenstein & Segui, 1997).

Mixed results were also found in social anxiety as well as in obsessive-compulsive disorder (OCD) samples, with some studies reporting evidence for content specificity (Becker, Rinck, Margraf, & Roth, 2001; Olatunji, Ciesielski, & Zald, 2011), while others failed to find enhanced processing bias when the content of the stimuli was congruent with the anxiety type studied (Foa, Ilai, McCarthy, Shoyer, & Murdock, 1993; Kampman et al., 2002). This inconsistency across studies along with the theoretical and practical implications outlined above articulates the need for a systematic quantitative review of this literature.

In the current meta-analysis we go beyond the primary question of whether content specificity of attention bias to threat in anxiety exists by testing the role of potential moderators of this effect. We tested: a) whether stimulus specificity is evident in specific anxiety disorders and perhaps not (or to a lesser extent) in others; b) whether the type of attention task used to measure threat bias moderated the magnitude of the effects. Specifically, evidence for attention bias specificity in anxiety is derived mainly from studies utilizing the emotional Stroop task (Williams, Mathews, & MacLeod, 1996) and the dot-probe task (MacLeod, Mathews, & Tata, 1986), both allowing computation of a general threat bias index. However, it is also commonly acknowledged that each of these tasks taps into different cognitive processes. The emotional Stroop effect is thought to reflect processes of threat-related interference, and even threat driven general slow-down that is not attentional (Algom, Chajut, & Lev, 2004). In contrast, the dot-probe task is thought to reflect visual-spatial attention. Since the two tasks may reflect different cognitive mechanisms contributing to the diversity in bias specificity effects, we tested task type as a potential moderator; c) whether the nature of the disorder-incongruent comparison stimuli (general threat or threat specifically related to a different anxiety disorder) affect the magnitude of attention bias specificity; and finally, d) we tested whether participants' age (youth under 18 years of age vs. adults) affected the magnitude of the bias specificity effect.

Answers to these questions can inform theoretical conceptualizations and future research as well as clinical decision in the development of attention bias modification protocols.

2. Methods

2.1. Literature base

A flow diagram of samples selection is provided in Fig. 1. Studies were collected through a search of the PsycInfo and PubMed databases using the key words *attention**, *bias**, *specific**, *content**, *relevant** intersected with *anxi** (anxiety), *phob** (phobia), *PTSD*, *OCD*, *panic*. The references of all the obtained articles were systematically searched for additional relevant studies. This search yielded 47 samples from 40 articles that were potentially eligible for inclusion in the meta-analysis (see inclusion criteria below). Included data were derived either directly from the information published in the articles, or, when the relevant calculations were not possible, from data provided to us through

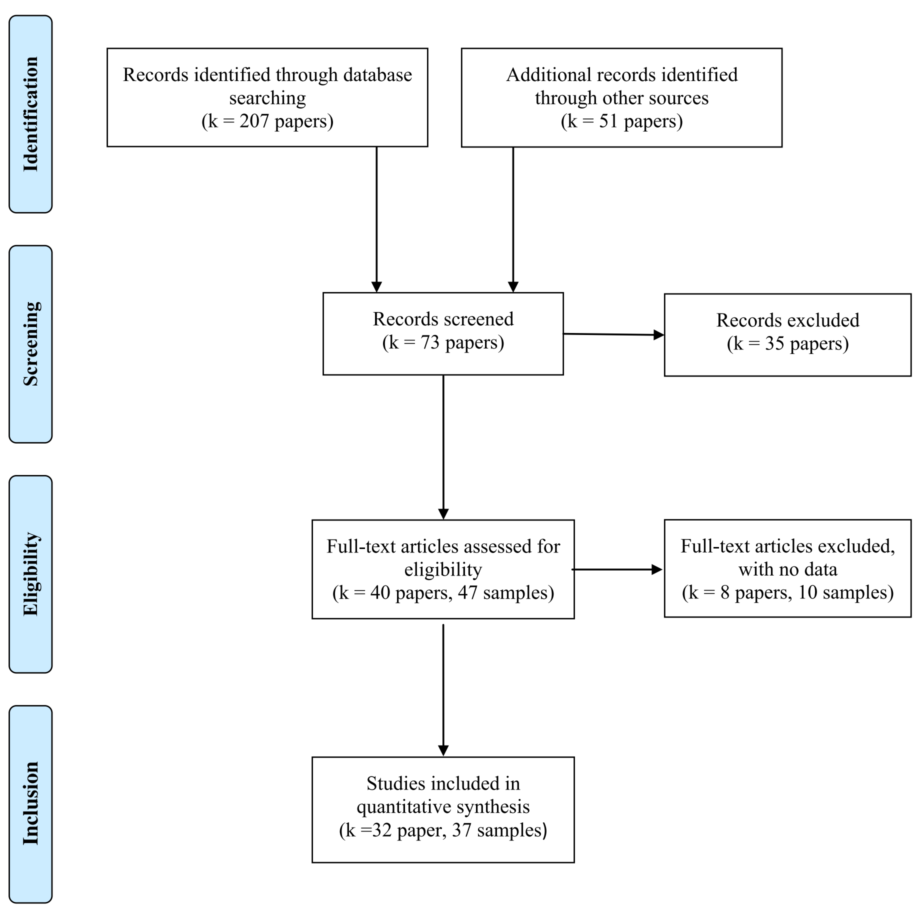

Fig. 1. Flow diagram of sample selection process.

contact with the authors. Data was not available for 10 samples, therefore a total of 37 samples were included in the meta-analysis reflecting an accumulation of 866 participants across samples (see Appendix A for list of the papers included in the meta-analysis).

2.2. Inclusion and exclusion criteria

1. The study was published as a journal article in the English language until November 2013.
2. The study included a group of clinically anxious participants formally diagnosed with a listed anxiety disorder. Samples of participants with generalized anxiety disorder (GAD) were excluded because no threat stimuli could be considered specifically congruent with this disorder. Studies targeting content specificity with non-clinical samples were also excluded from formal analyses (Hunt, Keogh, & French, 2006, 2007; Kaur, Butow, & Sharpe, 2013; Keogh, Ellery, Hunt, & Hannent, 2001; Mathews & Sebastian, 1993; Vasey, El-Hag, & Daleiden, 1996) because threat-content criteria for these anxiety types (e.g., anxiety sensitivity, fear of pain) are considerably less standardized, thereby complicating decisions on anxiety content-congruency [2].
3. The study used a response time (RT)-based visual attention task to assess threat-related attention bias (e.g., emotional Stroop, dot-probe, visual search, and rapid serial visual presentation - RSVP).
4. The study allowed a within group comparison of specificity bias by using disorder-congruent as well as disorder-incongruent threat stimuli, based on the following definitions:

   Disorder-congruent stimuli were considered as such when representing anxiety evoking objects, states, or ideas specifically relevant to the anxiety disorder studied. For example, disorder-congruent threat stimuli for snake phobia would be pictures of snakes or words related to snakes (Wikström, Lundh, Westerlund, & Högman, 2004). Alternatively, words related to being scrutinized by others such as “failure” could be considered as disorder-congruent stimuli for social anxiety disorder (Kindt, Bögels, & Morren, 2003). Studies using disorder-congruent stimuli but with varying levels of intensity and no disorder-incongruent stimuli were excluded (Ehlers, Margraf, Davies, & Roth, 1988; McNally, Riemann, & Kim, 1990; Spector, Pecknold, & Libman, 2003).

   The validity of stimuli-disorder congruence was described by authors of the included samples in various ways: face validity such as clinical judgment (e.g., Asmundson & Stein, 1994), usage in previous studies (e.g., Kyrios & Iob, 1998), or based on a pilot study (e.g., Kampman et al., 2002). It was not possible to track this factor for formal moderator analysis and thus we accepted authors' experimental claims.
   Disorder-incongruent comparison stimuli were of two types: a) stimuli that are specifically congruent with the threat content of another anxiety disorder (e.g., comparison between panic-related words and OCD-related words in patients with panic disorder (Kampman et al., 2002); or b) general threat stimuli.
5. The statistical contrast provided in the article allowed an estimation of the content specificity effect based on comparison either between attention bias index or interference index of the disorder-congruent versus the disorder-incongruent threat stimuli, or between the average response times (RTs) of these two threat stimuli types. Whenever both comparisons were available, the index-based contrast was preferred because it represents a more accurate measure of attention bias. At any event, no difference emerged between the combined effect sizes of these two types of contrasts, $Q = 0.01$, $p = 0.91$. Therefore, all results are reported collapsing across this moderator.

2.3. Coding system and coding decisions

A standard coding system was used. For each study, we coded the type of anxiety disorder participants had, whether the participants were youth (less than 18 years of age) or adults, and the task used to measure attention patterns (dot-probe, emotional Stroop, or other visual search task). We also noted the type of disorder-incongruent stimuli used in the study (general or specific to another anxiety disorder). When a study included both types of disorder-incongruent threat stimuli (e.g., Maidenberg et al., 1996), we preferred the general threat data. This decision was made on the assumption that general threat stimuli provide a broader variety of disorder incongruent threats compared to threats which are specific only to one other anxiety disorder, therefore allowing a more edifying answer to the content specificity question. Inter-coder reliability for the moderator variables was established for 15% of the included samples between two coders, with full agreements on all moderators (Kappa = 1).

2.4. Meta-analytic procedures and publication bias analyses

Cohen's d, reflecting the difference between means of two conditions divided by their pooled standard deviation, was the effect size index used to represent the bias specificity effect in the current meta-analysis. Positive d values reflect greater attention bias toward disorder-congruent threat stimuli as compared to disorder-incongruent threat stimuli. A negative d value reflects the opposite pattern. Cohen's d was computed based on t, F, or p statistics that represented the within-group contrast between these two threat stimuli types. When the contrast was reported for separate conditions that represented both components of attention bias, we calculated a combined effect size across conditions (e.g., Pineles, Shipherd, Mostoufi, Abramovitz, & Yovel, 2009). In cases where a contrast was neither reported in the paper nor provided by the authors, but the report allowed inference about significance and direction of the effect, we calculated an estimation for significant and for non-significant effect sizes, applying $p = 0.05$ (e.g., Beck et al., 1992) or $p = 0.50$ (e.g., McNally, English, & Lipke, 1993), respectively. The rational for these choices is embedded in our striving to represent as many effects as possible and provide the most comprehensive view of the extant literature. These standard estimation procedures allowed inclusion of reported effects based on even minimal but still reliable information.

Moderator analyses were conducted if a sufficient number of studies ($k \geq 4$) was obtained for each of the moderator's categories. The effects of moderator variables were estimated using the Q-test for within-group contrasts.

To examine possible publication bias, we conducted Egger's test for funnel plots asymmetry and computed fail-safe numbers. Egger's test is based on a linear regression of the effect sizes divided by their standard errors on their precision defined as the reciprocal of the standard errors (Rothstein, Sutton, & Borenstein, 2005). The fail-safe number is the number of studies with average sample size and non-significant outcomes that would be required to bring the combined effect size of the meta-analysis down to a non-significance level (Mullen, 1989). The Trim-and-Fill method was also used to test the influence of possible adjustments to the estimated effect due to publication bias (Duval & Tweedie, 2000).

All computations and analyses were carried out using the Comprehensive Meta-Analysis Software, version 2.002 (Biostat, Englewood, New Jersey). Since the datasets are heterogeneous and because random effects models are more conservative than fixed effects parameters in such cases, the combined effect sizes and their confidence intervals (CIs) are presented in the context of random effects models.

[2] For completeness, the combined content specificity effect size for non-clinical samples is $d = 0.31$, $p < 0.01$, $k = 9$, which was not significantly different from the overall combined effect size found for clinical samples.

Study	Anxiety Disorder	Incongruent stimuli	Cohen's *d*
Ashley et al. 2013	PTSD	general	0.93**
Asmundson et al. 1992	Panic	specific	0.50*
Asmundson et al. 1994	SAD	specific	0.57**
Beck et al. 1992	Panic	specific	-0.15
Becker et al. 2001	SAD	general	0.39*
Buckley et al. 2002	Panic	specific	1.28**
Buckley et al. 2002	PTSD	specific	-0.46*
Chen et al. 2013	Panic	general	0.62**
De Cort et al. 2008	Panic	general	0.27
Elsesser et al. 2004	PTSD	general	0.10
Fleurkens et al. 2011	PTSD	specific	0.54
Foa et al. 1993	OCD	general	0.14
Foa et al. 1991	PTSD	specific	0.55*
Grophalis et al. 2013	Panic	specific	-0.04
Horenstein et al. 1997	Panic	specific	-0.17
Horenstein et al. 1997	SAD	specific	-0.17
Kampman et al. 2002	OCD	specific	0.03
Kampman et al. 2002	Panic	specific	0.03
Kaspi et al. 1995	PTSD	general	0.50**
Kindt et al. 2003	SepAD	specific	0.10
Kindt et al. 2003	SAD	specific	-0.10
Kyrios & Lob 1998	OCD	general	-0.18
Litz et al. 1996	PTSD	specific	0.14
Lundh et al. 1996	SAD	specific	0.18
Lundh et al. 1999	Panic	specific	0.14
Maidenberg et al. 1996	Panic	specific	-0.18
Maidenberg et al. 1996	SAD	specific	0.18
McNally et al. 1993	PTSD	specific	0.42*
McNally et al. 1994	Panic	general	0.15
Moradi et al. 1999	PTSD	general	0.43*
Olatunji 2001	OCD	general	0.49**
Pineless et al. 2009	PTSD	general	0.00
Ribchester et al. 2010	PTSD	general	0.21
Thrasher et al. 1994	PTSD	general	0.77*
Vrana et al. 1995	PTSD	general	0.63**
Wikstrom et al. 2004	SP	specific	1.22**
Winner et al. 2012	Panic	general	0.26
Overall effect size			0.28**

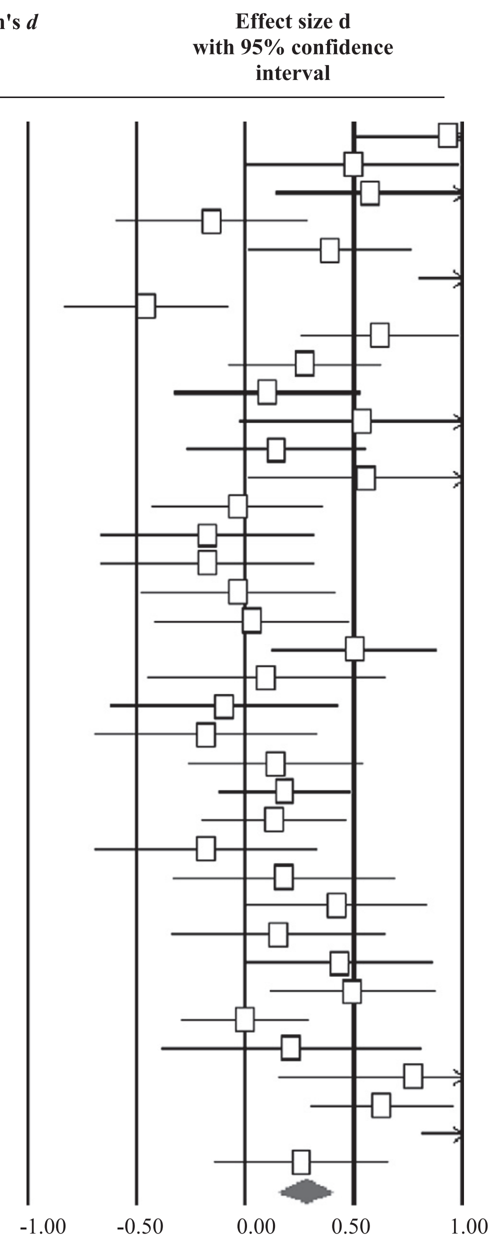

Fig. 2. Effect sizes and characteristics of studies included in the meta-analysis. For complete references, see Appendix A. The forest plot presents sample size by the relative size of the square and the diamond represents the combined effect size. PTSD = post-traumatic stress disorder; SAD = social anxiety disorder; OCD = obsessive compulsive disorder; SepAD = separation anxiety disorder; SP = specific phobia. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$.

3. Results

Study characteristics and effect sizes for each of the 37 samples included in the meta-analysis, alongside a forest plot of the effects, are presented in Fig. 2. The overall combined effect size of content-specificity was significant with *Cohen's* $d = 0.28$, $p < 0.0001$. This effect represents a greater threat-related attention bias for stimuli that are disorder-congruent relative to disorder-incongruent. Egger's test indicated no publication bias for this combined effect size, intercept = 0.22, $p = 0.89$ (2-tails), with no indication for bias also when using the trim and fill method. Fail-safe number analysis indicates that this effect would be reduced to insignificance only with the addition of 536 new studies with null results. Further inspection across samples revealed no outliers with standardized effect that exceeded ±3 standard deviations.

3.1. Moderator analyses

Combined effect sizes and confidence intervals for moderator analyses of the bias specificity effect are provided in Table 1. Below, we describe the results for the main moderator analyses.

3.1.1. Anxiety disorders

Combined effect sizes were computed for each anxiety disorder separately. PTSD samples yield a significant effect size of content specificity with larger effects detected for disorder-congruent relative to disorder-incongruent stimuli, $d = 0.35$, $p = 0.001$, $k = 13$. A significant effect was also found for panic disorder, $d = 0.23$, $p = 0.04$, $k = 12$. A similar but non-significant pattern was observed for social anxiety disorder samples, $d = 0.20$, $p = 0.056$, $k = 6$. A non-significant effect was

Table 1
Attention bias specificity effect size and moderator analysis.

	k	N	d	p	95% CI	Q for heterogeneity (p)	Q for contrast (p)
Overall effect	37	866	0.28	0.001	0.16, 0.36	109.82 (.001)	——
Age group							
Adults	32	780	0.29	0.001	0.15, 0.43	106.44 (.001)	0.36 (.55)
Youth	5	86	0.21	0.054	-0.004, 0.43	2.56 (.63)	
Anxiety disorder							
PTSD	13	301	0.35	0.001	0.14, 0.56	38.71 (.001)	1.65 (.65)
Panic disorder	12	244	0.23	0.04	0.009, 0.44	34.55 (.001)	
SAD	6	140	0.20	0.056	-0.005, 0.41	7.22 (.21)	
OCD	4	87	0.14	0.36	-0.16, 0.43	5.38 (.15)	
Paradigm							
Stroop	29	729	0.31	0.001	0.17, 0.46	90.67 (.001)	1.53 (.22)
Dot-probe	6	115	0.12	0.41	-0.16, 0.39	10.70 (.06)	
Incongruent stim. type							
Specific to another anxiety	21	657	0.21	0.03	0.02, 0.40	76.68 (.001)	1.45 (.23)
General threat	16	209	0.36	0.001	0.22, 0.50	28.07 (.02)	

observed for OCD, $d = 0.14$, $p = 0.36$, $k = 4$. Other anxiety disorders (i.e., separation anxiety and specific phobia) were not represented by sufficient number of studies to conduct a meaningful analysis ($k = 1$ each). The test for a difference between the combined effect sizes of the 4 anxiety disorders that had enough samples ($k \geq 4$) reveled a non-significant effect, $Q = 1.65$, $p = 0.65$. Further comparisons between all possible pairs of these four anxiety disorder yielded non-significant differences between disorders' combined effect sizes (all *ps* > 0.05).

3.1.2. Age group

The combined effect size of content specificity was significant among adult samples, $d = 0.29$, $p < 0.001$, $k = 32$, as well as among samples of youth, $d = 0.21$, $p = 0.05$, $k = 5$. The effect sizes of the two age groups did not differ significantly, $Q = 0.36$, $p = 0.55$.

3.1.3. Task type

Separate combined effect sizes were computed for samples using the emotional Stroop task and the dot-probe task to measure threat-related processing bias. Studies using the emotional Stroop task yielded a significant content specificity effect, $d = 0.31$, $p < 0.001$, $k = 29$. A non-significant effect was revealed for studies using the dot-probe task, $d = 0.12$, $p = 0.41$, $k = 6$. However, the contrast between the combined effect sizes of the two tasks was not significant, $Q = 1.53$, $p = 0.22$.

3.1.4. Type of disorder-incongruent stimuli

There was a non-significant difference ($Q = 1.45$, $p = 0.23$) between the combined effect size of samples using general threat as the disorder-incongruent stimuli, $d = 0.36$, $p < 0.001$, $k = 16$, and the combined effect size of samples using threat stimuli specific to other anxiety disorders, $d = 0.21$, $p = 0.03$, $k = 21$.

4. Discussion

The present meta-analysis provides support for the notion of attention bias specificity in anxiety by showing that among clinically anxious samples attention bias for threat stimuli that are disorder-congruent is larger relative to disorder-incongruent threat stimuli. The 37 samples included in this meta-analysis established a small but significant threat-bias specificity effect, which is not significantly moderated by age, type of anxiety disorder, different visual attention tasks, and the type of disorder-incongruent stimuli used as comparison. Further analyses reveal no evidence of publication bias suggesting that publications including reports on specificity bias were not dependent on whether or not the effect was significant. Indeed, for many of the relevant studies, the question of content specificity was not the primary research hypothesis, which may have facilitated a more balanced and unbiased response to the question at hand through meta-analysis.

The results provide evidence for specific, content-based, selective attention processing in clinically anxious populations, going beyond the established threat versus neutral bias previously reported in anxiety and anxiety disorders (Armstrong & Olatunji, 2012; Bar-Haim et al., 2007). It seems that the specific nature of the anxiety disorder may influence information processing priority in a way that creates reactivity not only for a generic threat but also increased sensitivity for specific threat contents. The current meta-analytic results are therefore in line with the assumption that anxiety is associated with distinctive patterns of processing of personally-relevant threat information (Mathews & Macleod, 1994), and with cognitive models emphasizing the role of schema-driven processing when allocating attention to threat stimuli (Bar-Haim et al., 2007; Beck & Clark, 1997; Mogg & Bradley, 1998; Öhman, 1996). The revealed effect of attention bias specificity suggests that attention allocation patterns could be affected by previous learning and memories. These content specificity effects could be at play in addition to or in interaction with general and more generic patterns of attention allocation, threat reactivity, and deficits in attention control.

As for evidence of specificity effect in different anxiety disorders, the current meta-analysis revealed content specificity in PTSD, panic disorder, and potentially also in social anxiety disorder but not in OCD. Kyrios and Iob (1998) suggest that idiographic specificity may be more salient in OCD patients than in other anxiety groups, since the phenomenological presentations of OCD are characterized by limited and stereotyped obsessions and compulsions that vary widely across patients. Thus, the extant studies testing bias specificity effect might have been too general in stimuli section rendering them not specific. This possibility could be tested in studies with OCD patients that employ threat stimuli that are idiosyncratically threatening to each participant. However, in relation to the meta-analysis finding concerning OCD, this route should be followed with caution, taking into consideration that in the current meta-analysis: a) the effect size of bias specificity in OCD samples, though not significant, was in the same direction as that of the other anxiety disorders; b) that the derived effect size was based on a small number of samples ($k = 4$); and c) that there was no significant difference between effect sizes of the different anxiety disorders.

Formal analysis of task type moderation of bias specificity reveals that the difference between studies relying on the emotional Stroop or the Dot-probe tasks is not significant. Inspection of the magnitude of the combined effect sizes for these tasks suggests that while the emotional Stroop appear to carry the weight of the significant combined effect, effect sizes of both tasks were in the same direction. It has been suggested that these two tasks may be related to different cognitive processes (Bar-Haim et al., 2007). While the emotional Stroop effect is thought to reflect processes of threat-related interference (Algom et al., 2004), the dot-probe task (MacLeod et al., 1986) is thought to reflect allocation of spatial–visual attention. While pointing to a content specificity effect, the current findings cannot yet specify the exact nature of the interaction between this content specificity effect and the underlying sub-processes of attention. Such knowledge could be gained by future experimental research that manipulates and controls both content specificity and measurement of specific attentional processes. In addition, the current results represent conscious perception of the threat stimuli (supra-threshold presentations), as it was not possible to evaluate the specificity effect in subliminally presented stimuli due to the small number of relevant studies. Future studies using different visual attention tasks and including subliminal presentations as well, could tap into the role of different attentional and perceptual processes in relation to bias specificity in anxiety.

Beyond the basic interest in cognitive mechanisms associated with anxiety, the issue of attention bias specificity is of interest to the development of novel clinical treatments, in particular for the growing research on ABMT efficacy. The small but significant specificity bias effect found here could inform research on therapeutic designs that could enhance ABMT efficacy. Meta-analyses of ABMT efficacy indicate small-to-medium effect sizes for anxiety reduction (Beard et al., 2012; Hakamata et al., 2010; Hallion & Ruscio, 2011; Mogoase et al., 2014). These relatively small effects invoke discussions concerning possible factors that could optimize and enhance therapeutic effects. One such factor is the nature of stimuli being used for attention training. Although the current results do not directly inform whether disorder-congruent threat stimuli produce a stronger anxiolytic effects in ABMT, the results do imply that use of stimuli that are congruent with the content of the anxiety disorder being targeted may result in stronger activation of underlying neuro-cognitive mechanisms and thereby increase ABMT efficacy.

Future research could further explore an even higher order of content specificity not examined in the current meta-analysis, venturing beyond disorder-congruent content to consider idiosyncratic content that is personalized and tailored to a specific patient. Such an approach could enable testing processing specificity in a disorder like GAD, in which the content of stress and worry is non-specific and varies markedly across patients. Early studies attempted to addressed the issue of content specificity in high-trait anxious individuals (also assumed to have variable general worries) by looking at differential attention bias in sub-groups of participants characterized by core domains of concerns (e.g., social concerns, physical concerns, MacLeod et al., 1986). However, given the currently available computational capacities, individual patients could be allowed to select the specific contents most relevant to their concerns and these could be directly embedded in the measurement and training tasks. Such personalized approach to content specificity could afford greater modularity in ABMT protocols that may enhance therapeutic effects. In conclusion, it may be practical to keep some aspects of ABMT protocols standard across different disorders (e.g., presentation speed, number of trials per session, number of sessions). In contrast, use of disorder-congruent or maybe even individualized content for training and measurement should be seriously considered. These inferences are in line with current perspective of diagnosis and treatment which refers to psychopathology through a dimensional view of neuro-cognitive domains deficits, taking into account the dialectics between disorder specificity on the one hand and cross diagnostic general mechanisms on the other hand (e.g., National Institute of Mental Health's Research Domain Criteria Project (RDoC), Etkin & Cuthbert, 2014; Insel et al., 2010).

Some limitations and suggestions for future research can be noted. First, the current meta-analysis is based on studies performed with relatively small samples that were possibly underpowered to detect content specificity effects. The combined effect size of $d = 0.28$ for the contrast between disorder-congruent and disorder-incongruent threat stimuli, implies that single studies should consist of samples of at least 81 participants to have enough power to find a significant contrast (power = .80, alpha < .05, one-tailed). Hence, replications with larger samples are needed to further establish the bias specificity effect in anxiety disorders. However, this concern is somewhat 'softened' by the fact that no publication bias was evident in the data. Second, it is worth noting that most of the samples in the moderator analyses remain heterogeneous, implying that even subgroup effects vary substantially and this variance cannot yet be explained. Third, an important limitation of the current analysis pertains to the difficulty in estimating comorbidity within the anxiety samples. Research has consistently shown that more than 50% of anxious patients suffer from at least one additional current anxiety or mood disorder (Kessler, Chiu, Demler, & Walters, 2005; Merikangas & Swanson, 2010; Newman, Przeworski, Fisher, & Borkovec, 2010) and thus different types of threat contents could be congruent with patients' anxieties. Although we made an attempt to document co-morbidity in the current meta-analysis, the diversity of criteria and manners of reporting made it impossible to evaluate the impact of comorbid anxiety disorders on threat-bias specificity across studies. Some studies excluded patients with comorbid disorders (e.g., Buckley et al., 2002; Horenstein & Segui, 1997), some studies did not exclude participants due to comorbidity, but rather reported its prevalence in their sample (e.g., Lundh, Wikström, Westerlund, & Őst, 1999), still others only specify inclusion but not exclusion criteria (e.g., De Cort et al., 2008). Given the high rates of comorbidity in anxious populations, this issue deserves further examination.

In conclusion, though there is still much to be learned about mechanism of threat-related attention bias in anxiety, the present meta-analysis indicates that this attentional bias does not solely reflect dysfunctions in general reaction to threat or generic attentional mechanisms, but also includes associations with specific content themes that interact with attention deployment during threat processing. There have been also some attempts to investigate neural correlates of content specificity in attentional bias and to characterize distinguished neurocognitive patterns across different anxiety disorders. For example, van den Heuvel et al. (2005) found specificity effect in neural response for disorder-congruent threat stimuli, involving mainly ventral brain regions in OCD patients, while PD patients showed different patterns involving also widespread dorsal brain regions. Future research could further apply neuro-imaging methods in order to investigate neurological processes of attention bias specificity. Finally, ABMT should start considering disorder-congruent training stimuli in their attempts to optimize treatment parameters.

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Contributors

Lee Pergamin-Hight, Reut Naim and Yair Bar- Haim designed the study and wrote the protocol. Lee Pergamin-Hight and Reut Naim conducted literature searches, provided summaries of previous research studies and conducted the statistical analysis. Yair Bar-Haim, Marinus van IJzendoorn, and Marian Backermans-Kranenburg provided feedback on the statistical approach and edited drafts of the manuscript. All authors have approved the final manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

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Appendix A. Studies included in the meta-analysis

Ashley, V., Honzel, N., Larsen, J., Justus, T., & Swick, D. (2013). Attentional bias for trauma-related words: Exaggerated emotional Stroop effect in Afghanistan and Iraq war veterans with PTSD. *BMC Psychiatry, 13*.

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