Journal of Anxiety Disorders 64 (2019) 79–89

Contents lists available at ScienceDirect

Journal of Anxiety Disorders

journal homepage: www.elsevier.com/locate/janxdis

Review

An integrative review of the vigilance-avoidance model in pediatric anxiety disorders: Are we looking in the wrong place?

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ARTICLE INFO

Keywords:
Attention bias
Anxiety
Children
Development
Review

ABSTRACT

Enduring cognitive models of anxiety posit that negative biases in information processing are implicated in the etiology, maintenance, and recurrence of anxiety disorders in youth and adults. Specifically, the vigilance-avoidance model of attention is an influential hypothesis proposed to explain anxious individuals' attentional patterns. The vigilance-avoidance model posits that anxious individuals, relative to nonanxious individuals, initially orient more quickly to threatening stimuli and then later avoid threatening stimuli. However, a large body of empirical research examining attentional mechanisms in anxious individuals uses paradigms that do not allow the measurement of the time course of attention. Furthermore, existing reviews that examine the time course of attention only include studies with adults. We systematically review in depth the literature that compares anxious and non-anxious children that takes advantage of research designs that allow the examination of the time course of attention. Across studies, there is not robust support for the vigilance-avoidance model in samples of anxious youth. Future research examining attention biases across time should employ tasks that more directly measure multiple stages of attention, in order to assess if vigilance-avoidance patterns emerge based on sample characteristics or task variables, and to inform intervention efforts.

1. Introduction

Anxiety disorders commonly emerge in childhood and adolescence, affecting 10–15% of youth at any point in time, with a median age of onset at around 11 years (Costello, Egger, & Angold, 2005; Kessler et al., 2005; Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012). Pediatric anxiety disorders are associated with a diminished quality of life and continued adverse outcomes in adulthood (Beesdo, Knappe, & Pine, 2009; Woodward & Fergusson, 2001). While effective treatments exist for anxiety disorders (e.g., cognitive-behavioral therapy (CBT)), first-line interventions for clinical pediatric anxiety only have treatment response rates ranging from 50 to 60% (Kendall et al., 1997; James et al., 2005; Walkup et al., 2008). Thus, more research is necessary to identify pathways by which individuals develop anxiety disorders in order to design targeted prevention and intervention strategies. The present review provides theoretical and empirical background on attention bias in anxious youth and specifically investigates whether a popular theoretical model that is thought to explain the development of anxiety disorders in youth, the vigilance-avoidance model of attention bias, is supported in the literature. Uncovering patterns of attentional bias in anxious youth may have far-reaching intervention implications.

2. Cognitive models of anxiety disorders

Psychological theories of anxiety disorders in both adults and children largely focus on cognitive models to explain the acquisition and maintenance of anxiety. Beck (1976) famously developed a cognitive framework to understand anxiety and depressive disorders in adults. Later, Beck and Clark (1997) elaborated on this cognitive theory, proposing that anxiety is a result of dysfunction at varied levels of informational processing. Information processing refers to the steps by which information is relayed through cognition, which includes cognitive processes such as attention, memory, and interpretation (Massaro & Cowan, 1993). Cognitive biases refer to when cognitive processes, such as attention memory, and interpretation, preferentially process certain types of information. Many information-processing models of anxiety disorders consider cognitive biases to occur both automatically and strategically during information processing (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007; Beck & Clark, 1997; Mathews & Mackintosh, 1998; Öhman, 1996).

According to Beck and Clark's cognitive model (1997), cognitive

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https://doi.org/10.1016/j.janxdis.2019.04.003
Received 28 December 2018; Received in revised form 3 April 2019; Accepted 6 April 2019
Available online 19 April 2019
0887-6185/

biases (i.e., attention, memory, and interpretation) are theorized to contribute to the onset of anxiety disorders and thus are often considered to be targets for treatment. A large body of evidence supports biased attention toward threat in anxiety disorders (e.g., Bar-Haim et al., 2007). Attention biases have been implicated in downstream dysfunctional information processing (e.g., interpretation) in individuals with anxiety disorders, further signifying their importance in cognitive models of anxiety (Beck & Clark, 1997; Mogg & Bradley, 1998). Given the relationship between attention biases and anxiety disorders and the implications that attention biases have for information processing, attention biases are the focus of the current review.

Attention bias in anxiety has been widely studied for the past three decades, specifically focusing on how anxious individuals selectively attend to threatening stimuli in the environment at both automatic and strategic levels of processing. At the automatic level, the most prominent theories of attention bias in anxiety have proposed a bottom-up, threat detection mechanism, responsible for automatically facilitating attention toward threatening stimuli (Bar-Haim et al., 2007; Beck & Clark, 1997; Eysenck, Derakshan, Santos, & Calvo, 2007; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Öhman, 1996; Williams, Watts, MacLeod, & Mathews, 1988). Models have also posited that attention biases occur at the strategic level of information processing, in which an individual's top-down goals can either serve to maintain or shift attention toward threat (Eysenck et al., 2007).

The specific mechanism of the relationship between attention biases and anxiety is debated in the literature. While some researchers propose that attention biases toward threat increase anxiety (Bar-Haim et al., 2007; Beck & Clark, 1997), others argue that anxiety disrupts attentional patterns (Eysenck et al., 2007; Mogg & Bradley, 1998; Williams et al., 1988). These mechanisms likely do not work in isolation and are likely bidirectional; selective attention to threat in anxious individuals may create a dysfunctional cycle that perpetuates anxiety. Studies have attempted to experimentally manipulate attention bias and anxiety variables to clarify the mechanisms.

One of the ways researchers have manipulated attention bias is by using attention bias modification (ABM), a process in which attention is retrained via implicit processes. ABM has been used to experimentally alter attention biases to both increase attention to threat and decrease attention from threat (Hakamata et al., 2010; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). Generally, ABM interventions are designed to train attention to focus away from threatening stimuli. Experimentally reducing attention bias via ABM has been found to have a modestly robust effect on reducing anxiety symptoms; however, effects may be exaggerated due to a file-drawer problem (Jones & Sharpe, 2017). There is also evidence that the degree to which attention bias is reduced corresponds to the magnitude of anxiety symptom reduction, such that greater reduction in attention bias to threat was associated with greater anxiety symptom reduction (Mogoaşe, David, & Koster, 2014; Price, Greven, Siegle, Koster, & De Raedt, 2016). However, ABM interventions treat attention bias as a unitary index, although differentiated components of attention bias may be more effective targets to modify.

3. Attention system

Posner and Petersen (e.g., Posner & Petersen, 1990) notably outlined three neural networks involved in attention, namely the alerting network (prepares individuals to receive and respond to stimulus), the orienting network (orients attention toward external stimulus), and the executive network (top-down, effortful control of attention). Their original model has since been updated to reflect updated evidence for a more complex system (i.e., Petersen & Posner, 2012). Currently, there is evidence for two brain systems involved in orienting to external stimuli—the dorsal attention system, which provides top-down visuospatial guidance of attention, and the ventral attention system, which is involved in bottom-up reorienting of attention (Corbetta & Shulman, 2002). Additionally, their updated model identifies two separate executive attention networks, both of which are implicated in top-down, effortful control of attention. The frontoparietal control system is involved in task-switching, while the cingulo-opercular system, is involved in task maintenance (Dosenbach, Fair, Cohen, Schlaggar, & Petersen, 2008).

During the initial orienting of attention, visual attention focuses on a stimulus, giving this stimulus preferential processing resources and reducing interference from other stimuli in the environment (see Raz & Buhle, 2006; Ungerleider & Kastner, 2000). Orienting of attention can be directed by both stimulus-driven (i.e., exogenous stimuli capture attention; bottom-up) and goal-directed (i.e., endogenous goals guide attention; top down) processes (Egeth & Yantis, 1997), reflecting two subserving neural networks (Petersen & Posner, 2012). Orienting of visual attention can occur covertly, meaning eye movements do not match the attentional direction (Findlay & Gilchrist, 2003; Weierich, Treat, & Hollingworth, 2008). Additionally, orienting can occur covertly, meaning that the eye gaze matches the attentional direction, or covert and over attention can co-occur. Generally, covert and overt attention are associated processes, with overt attention guiding covert attention (Findlay & Gilchrist, 2003). Neuroimaging research supports this theory, finding that the same neural networks serve both covert and overt initial orienting of visual attention (Corbetta et al., 1998; De Haan, Morgan, & Rorden, 2008).

While covert visual attention does not require eye movements to occur, overt visual attention is constrained by visual processing parameters. High-resolution visual processing is attained from the center region of the retina, which is known as the fovea. The fovea captures about 2° of the visual angle (Weierich et al., 2008). Thus, eye movements, known as saccades, are generally needed to selectively capture the part of the visual field of interest in order to process the visual field of interest in higher resolution. In between saccades, when the eyes are relatively stable, fixations occur and last approximately 300 ms on average (Henderson & Hollingworth, 1998). Fixations enable further processing of visual information. When examining attention to threat, researchers using eye-tracking methodology are measuring more overt measures of attention, such as time spent fixating on threat or time taken to fixate on threat (i.e., latency). Reaction time assessments may be assessing both covert and overt attention; however, as stated previously, overt and covert attention are associated processes.

Manual reaction time studies have limited capability to delineate the time course of attention and instead present more of a "snapshot" picture of attention at specific time-points (Armstrong & Olatunji, 2012). For instance, it is possible that an individual could shift attention toward multiple stimuli before the end of the stimulus presentation time (before 500 ms or 1000 ms), and a reaction time measure could potentially only just reflect the last stimulus that he or she was attending towards. Furthermore, reaction time measurements can be influenced by differences in motor capabilities, which can influence outcomes. In response, eye-tracking methodology has recently emerged as a favored method to continuously study visual attention over the course of attention. Eye-tracking allows the assessment of overt changes in visual attention.

3.1. Attention and development

While some attentional processes, such as orienting, do not undergo much change after infancy, attentional control mechanisms, which involve shifting of attention, have been shown to change across the course of development (Rueda et al., 2004). In infancy, the parietal regions of the brain, which are critical to orienting of attention, develop in the posterior attentional system early in life (Posner & Rothbart, 2007) and only undergo minor changes throughout development (Brodeur, Trick, & Enns, 1997). By age two, the anterior cingulate, which is implicated in self-regulation and attentional control processes, shows stronger connections to frontal areas and to later parietal areas of the brain.

Research with older children and adolescents shows that the anterior cingulate cortex becomes increasingly differentiated from the orienting network as one approaches adulthood, perhaps reflection specialization of the neural pathway and improved efficiency (Fair et al., 2009). While children and adults do not show differences in speed of orienting towards exogenous cues, the ability to disengage attention at will improves across development (Rueda et al., 2004).

Attention bias research in children is considered to be less consistent compared to research with adults, perhaps because of developmental changes that are occurring (Field, Hadwin, & Lester, 2011; Cisler & Koster, 2010; Puliafico & Kendall, 2006). A meta-analysis of attention bias studies (in which attention bias was considered as a unitary index) conducted in anxious and healthy children demonstrated that children with anxiety display a greater attention bias toward threat-related stimuli compared to non-anxious controls; however, healthy children showed a bias as well, albeit to a lesser extent than anxious children (Dudeney, Sharpe, & Hunt, 2015). Results of the meta-analysis revealed that stimulus time presentation was a significant moderator for these studies, finding stronger evidence for attention bias when the stimulus presentation were for a long interval (e.g., 1250 ms) (Dudeney et al., 2015). Additionally, age was also an important moderator of the between-group differences of attention bias toward threat for children (Dudeney et al., 2015). This meta-analysis supports a developmental theory of information processing, known as the moderation model, in which all youth may exhibit attention bias toward threat early in development, but—over the course of development—anxious youth continue to exhibit such bias while healthy youth become less biased (Field & Lester, 2010).

This review assessed whether there is support for a developmental model of attention bias in anxiety. While previous reviews have also examined developmental differences in attentional processing (e.g., Field & Lester, 2010; Waters & Craske, 2016), these reviews have chosen a broader, integrative focus that encompasses research on a wide-range of cognitive biases. The present review instead focuses exclusively on paradigms that allow for the examination of the time course of attention in order to test the specific question of whether the vigilance-avoidance model is supported in youth. In addition, in the present review, infant studies that examine attention bias using free-viewing, eye-tracking tasks will be included in order to examine developmental patterns that emerge early in life.

3.2. Stages of attention and anxiety

Anxiety has been theorized to influence attentional mechanisms at the initial orienting stage of attention and also at the later shifting stage of attention, when disengagement occurs (Cisler & Koster, 2010). In individuals with anxiety, exogenous threat cues may disrupt the top-down, goal-driven processing and reduce an individual's ability to control his or her initial direction of attention or later stages of attention (Eysenck et al., 2007). Given the different purposes and mechanisms involved in these early and late attentional processes (Petersen & Posner, 2012; Posner & Petersen, 1990) and the evidence that attentional stages might play a role in the relationship between attention biases and anxiety, research has sought to explain these relationships. Thus, different theories have been proposed to address the relationships between attention biases, attentional stages, and anxiety.

3.3. Attention Bias theories: integrating attention stages and anxiety

Different models have been proposed to reflect the associations between attention biases to threat, stages of attention, and anxiety. Three prominent models have emerged: the vigilance model, the vigilance-avoidance model, and the delayed disengagement model/attention maintenance model.

The vigilance model of attention suggests that individuals with anxiety more easily detect threat in the environment and more quickly orient their attention toward threat compared to individuals without anxiety (e.g., Beck & Clark, 1997). This model proposes that exogenous threat cues capture attention faster, due to a decreased threshold for threat detection in anxious individuals. A large meta-analysis of visual attention paradigms found anxious children to display vigilance toward threat with a medium effect size ($d = 0.38$) (Bar-Haim et al., 2007).

The vigilance-avoidance model of attention (Mogg & Bradley, 1998) has purported to explain anxious individuals' attentional patterns at both the orienting stage and later stages of attention. The vigilance-avoidance model posits that anxious individuals, relative to non-anxious individuals, quickly orient to threatening stimuli and then later avoid threatening stimuli. While initial orienting toward threat is thought to be due to bottom-up detection of exogenous treat, later avoidance is considered to be a strategic, top-down process by which anxious individuals are attempting to reduce arousal triggered by a threatening stimulus. While many studies have tested this model, only one review (Armstrong & Olatunji, 2012) explicitly examined this model. However, this review did not include empirical studies assessing youth.

The vigilance-avoidance attentional pattern may serve to maintain anxiety long-term, despite anxious individuals' attempt to reduce their anxiety via this attentional avoidance strategy in the short-term. By exposing and then quickly avoiding the feared stimulus, anxious individuals do not have time to process information that could contradict their beliefs about the threatening stimuli. Avoidant behaviors have been shown to maintain anxiety over time, whereas approach behaviors are associated with anxiety reduction (Hofmann, 2007).

Another model that attempts to integrate attention biases, attention stages, and anxiety is the delayed disengagement model (Fox, Russo, Bowles, & Dutton, 2001), or the attention maintenance model (Weierich et al., 2008), which is the term adopted in this review. This model focuses on later attention processes—shifting of attention. The attention maintenance model proposes that attention is not necessarily initially oriented toward the threatening stimulus, but once attention is focused on threatening stimuli, it takes longer for anxious individuals to shift his or her attention away from the threatening stimulus relative to non-anxious individuals, perhaps due to difficulty disengaging attention. While at first glance, it appears as if the vigilance-avoidance model and the attention maintenance model are in direct competition, Weierich et al. (2008) argue that they are not incompatible hypotheses. The attention maintenance hypothesis does not make any claims about the speed of initial orienting; therefore, the vigilance model may still be supported across both models. Additionally, for anxious individuals, it could be that while at the covert level of attention, attention maintenance on threat occurs in later stages of attention, while at the overt level of attention, there could be avoidance patterns, particularly during long viewing times of threatening stimuli. Therefore, when assessing if empirical research provides support for these attentional theories, it is important to consider whether the tasks are measuring covert or overt attention. While the review aims to examine if the vigilance-avoidance model is supported, it will be noted if the other models, the vigilance model or the attention maintenance model, better explain anxious children's attentional patterns in research that directly tests the vigilance-avoidance model.

4. Review aims

The focus of this paper is to evaluate if the vigilance-avoidance model, which has been the most prominent multi-attentional-stage model in anxiety, is supported in the literature. In order to accomplish this evaluation: *First*, we evaluated if the vigilance-avoidance model is supported in empirical research comparing anxious and non-anxious children that takes advantage of research designs that allow the examination of multiple stages of attention. Thus, we reviewed articles that utilize eye-tracking methodology in addition to articles that used reaction time methodology that allowed differentiation of stages of

attention. A meta-analysis was not feasible, given the small number of studies and major paradigm differences. Given that methodological differences (e.g., paradigm used, stimulus time presentation) may lead to conflicting results, we grouped articles by paradigm and highlighted differences in task characteristics (e.g., timing of presented stimuli). Furthermore, we emphasized any differences in results based on anxiety subtype and clinical anxiety status (compared to subclinical). *Second,* we compiled research evaluating children, assessing for evidence that attentional biases toward threat vary across development. *Third,* we made recommendations for improvement in methodology in the field, including arguments for refining eye-tracking methodology and improving the ecological validity of paradigms. *Fourth*, we discussed treatment implications based on the literature review.

This review integrates literature from developmental, clinical, and cognitive perspectives to assess if methodologically-sound research supports the vigilance-avoidance model and examine how attentional patterns change across the course of development.

5. Methods

Reviewed studies were obtained using electronic search of PubMed, PsychInfo, and Google Scholar using the following combination of search terms: attention, bias, vigilance, avoidance, disengagement, children, adults, anxiety, dot-probe, visual search and by examining citation lists of articles that were selected for the review. Studies were included in the review if they used paradigms that allowed the delineation of initial orienting from later stages of attention, included a healthy comparison group, and if the anxious populations used fell within anxiety disorder classification by the Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5; American Psychiatric Association, 2013). The literature search was conducted in March 2019. Published papers that met our inclusion criteria were published within 2009 and 2017.

5.1. Types of literature reviewed

5.1.1. Paradigms used to assess attentional bias

Given the variety of models attempting to explain the relationships between attention biases, attention stages, and anxiety symptoms, it is not surprising that researchers have used a wide variety of tasks to measure attention biases, including the emotional Stroop task, the dot-probe task, the emotional spatial cueing task, the visual search task, and the free-viewing task. However, only the dot-probe task (with modifications) and eye-tracking tasks are capable of delineating early and later attentional processes.

5.1.1.1. Dot-probe task. Recently, researchers have utilized a modified version of the dot-probe paradigm in order to better identify attention biases at the different stages of attention (MacLeod, Mathews, & Tata, 1986). In this task, participants first view a pair of faces or words, one emotional and one neutral. After typically 500 ms, the face or word pair stimuli disappear, and a probe appears in the prior location of either the emotional stimulus (congruent threat trials) or the neutral stimulus (incongruent threat trials). Participants make a motor response to indicate the location of the probe (i.e., a probe location task) or the type of probe (i.e., a probe identification task). When individuals respond faster to congruent threat trials compared to incongruent threat trials individuals are considered to have preferential attention or greater vigilance toward threat.

Some researchers incorporate eye-tracking into the dot-probe task (e.g., Mogg, Garner, & Bradley, 2007; Mogg, Millar, & Bradley, 2000), which allows the examination of overt attentional pattern during stimulus presentation. Attention vigilance is commonly calculated by comparing the probability of initial fixation on threat stimuli to neutral stimuli or by comparing the latency to fixate on the threatening stimuli to the neutral stimuli. Later stages of attention are generally calculated by either comparing duration of fixations on the threatening stimuli to duration on neutral stimuli in specified time periods (i.e., epochs) or by comparing the initial fixation duration on the threatening stimuli to the initial fixation duration on neutral stimuli.

Similar to other attention paradigms, there are limitations to the dot-probe task. While some have found the dot-probe task to be low to moderately reliable (Price, Kuckertz et al., 2014), others have failed to demonstrate reliability (Britton et al., 2013; Dear, Sharpe, Nicholas, & Refshauge, 2011; Schmukle, 2005; Staugaard, 2009; Waechter, Nelson, Wright, Hyatt, & Oakman, 2014), particularly for individual differences and for reaction time indices. Additionally, some critics (e.g., Cooper & Langton, 2006; Fox et al., 2001; Weierich et al., 2008) point out that it is possible for individuals to make multiple eye movements during the typical 500 ms presentation duration. Thus, a longer response to probes replacing the neutral stimulus may reflect either initial orienting preference (vigilance) *or* difficulty withdrawing attention from threat (attention maintenance). However, other researchers argue that it is possible to examine initial orienting separate from later increased maintenance or avoidance using two different stimulus time presentation periods (Bradley, Mogg, Falla, & Hamilton, 1998). Response times during trials with brief stimulus presentation times (i.e., around 500 ms) are considered to assess for initial biases in orienting. Trials with longer stimulus presentation times (i.e., around 1500 ms), on the other hand, are thought to assess for biases in later stages of attention. Attentional indices of interest based on the differing theoretical perspectives are summarized by paradigm in Table 1.

5.1.1.2. Visual search task. Another attention paradigm commonly used to measure attention biases is the visual search task, which has been modified to be used in conjunction with eye-tracking methodology. In this paradigm, participants view an array of objects (generally more than four to prevent a floor effect) and search for a target object, which is either a threatening or a non-threatening stimulus (e.g., Öhman, Flykt, & Esteves, 2001). Attention bias to threat is generally inferred by comparing duration taken to find a target threatening stimulus in a matrix of neutral stimuli compared to finding a target neutral stimulus in a matrix of neutral stimuli. Initial vigilance to threat is assumed when participants are faster at detecting the threatening target compared to the neutral target. Later maintenance of attention is assumed when individuals are slower at detecting a neutral target in a matrix of threatening stimuli or with one threatening distractor compared to the speed of detecting a neutral target with neutral distractors. A strength of this task in comparison to the dot-probe task is that the visual search task may be more ecologically valid because the visual search task involves more than two possible visual stimuli simultaneously, which may be more similar to everyday life (Weierich et al., 2008). One notable limitation to this task, however, is that increased time taken to detect the neutral target with threatening distracting stimuli, which is largely considered to reflect increased maintenance of threat (or difficulty disengaging or distraction by threatening stimuli), could be instead considered a reflection of greater initial vigilance, rather than an index of later attention. In other words, when individuals are slower at detecting a neutral target stimulus among threatening distractor(s), individuals could be simply initially drawn toward the threatening stimuli. Therefore, the slower response time for the target neutral stimulus could be a reflection of greater initial vigilance rather than increased maintenance on the threatening stimulus/stimuli.

5.1.1.3. Free-viewing task. The last commonly used task to assess attention biases at multiple stages of attention is the free-viewing eye-tracking task. In this task, participants passively view paired threatening and neutral stimuli. Stimuli used in these tasks are generally paired faces (angry and neutral) or paired pictures, such as ones from the International Picture System (IAPS; CSEA, Center for the Study of Emotion & Attention, 1999) with paired threatening pictures

Table 1
Summary of Theoretical Outcome Indices by Paradigm.

Paradigm	Initial vigilance	Initial avoidance	Later maintenance	Later avoidance
Reaction time dot-probe	Faster RT for probes replacing threatening stimuli compared to probes replacing neutral stimuli for shorter stimulus duration times (200–500 ms)	Slower RT for probes replacing threatening stimuli compared to probes replacing neutral stimuli shorter stimulus duration times (200–500 ms)	Faster RT for probes replacing threatening stimuli compared to probes replacing neutral stimuli for longer stimulus duration times (> 1000 ms)	Slower RT for probes replacing threatening stimuli compared to probes replacing neutral stimuli for longer duration times (> 1000 ms)
Eye-tracking dot-probe	Higher probability of initial fixation on threatening stimulus compared to neutral stimulus; Shorter latency to fixate on threatening stimulus compared to neutral stimulus; More fixations on threatening stimulus compared to neutral stimulus in initial epoch	Lower probability of initial fixation on threatening stimulus compared to neutral stimulus; Longer latency to fixate on threatening stimulus compared to neutral stimulus; Fewer fixations on threatening stimulus compared to neutral stimulus in initial epoch	Longer duration of initial fixation on threatening stimulus; More fixations on threatening stimulus compared to neutral stimulus in later epochs	Shorter duration of initial fixation on threatening stimulus; Fewer fixations on threatening stimulus compared to neutral stimulus in later epochs
Eye-tracking visual search	Shorter latency to fixate on threatening stimulus during trials with a threatening target and neutral distractors compared to neutral target trials; Shorter fixation time on neutral distractors during trials with a threatening target and neutral distractors compared to neutral target trials	Longer latency to fixate on threatening stimulus during trials with a threatening target and neutral distractors compared to neutral target trials; Longer fixation time on neutral distractors during trials with a threatening target and neutral distractors compared to neutral target trials	Shorter latency to fixate on threatening stimulus on trials with a neutral target and threatening distractor(s) compared to neutral distractor trials; Longer fixation time on threatening distractor(s) during trials with a neutral target and threatening distractor(s) compared to neutral distractor trials	Longer latency to fixate on threatening stimulus on trials with a neutral target and threatening distractor(s) compared to neutral distractor trials; Shorter fixation time on threatening distractor(s) during trials with a neutral target and threatening distractor(s) compared to neutral distractor trials
Eye-tracking free-viewing	Higher probability of initial fixation on threatening stimulus compared to neutral stimulus; Shorter latency to fixate on threatening stimulus compared to neutral stimulus; More fixations on threatening stimulus compared to neutral stimulus in initial epoch	Lower probability of initial fixation on threatening stimulus compared to neutral stimulus; Longer latency to fixate on threatening stimulus compared to neutral stimulus; Fewer fixations on threatening stimulus compared to neutral stimulus in initial epoch	Longer duration of initial fixation on threatening stimulus; More fixations on threatening stimulus compared to neutral stimulus in later epochs	Shorter duration of initial fixation on threatening stimulus; Fewer fixations on threatening stimulus compared to neutral stimulus in later epochs

(e.g., person holding a pistol) with neutral pictures (e.g., people in the street). Vigilance to threat is commonly assessed by calculating probability of initial fixation on the threatening stimulus and the latency to initial fixation on the threatening stimulus. Later attention biases are generally calculated by either comparing duration of fixations on the threatening stimuli to neutral stimuli in specified time periods (i.e., epochs) or by comparing the initial fixation duration on the threatening stimulus to the neutral stimulus.

5.1.1.4. Sample variables. Three prominent sample variables that have been subject to scrutiny and discussion in the anxiety attention bias field are anxiety subtype (e.g., social anxiety disorder vs. generalized anxiety disorder), type of high-symptom group (i.e., clinical vs. non-clinical levels of anxiety), and age of the samples (Armstrong & Olatunji, 2012; Bar-Haim et al., 2007; Dudeney et al., 2015). These sample variables are important factors to consider when drawing conclusions about the attention bias field in order to increase specificity of review findings. For instance, it may be that results are more consistent in a particular anxiety subtype or in clinical samples compared to analogue samples (i.e., non-clinical samples), or in children over a certain age.

Meta-analyses have examined whether these sample-related variables (i.e., high-symptom group, anxiety subtype, and age) are significant moderators of attention bias between-groups. In the meta-analyses that analyzed adult studies or analyzed a mixture of adult and child studies, anxiety subtype and type of high-symptom group were not significant moderators, finding that effect sizes did not differ across these variables for vigilance to threat (Armstrong & Olatunji, 2012; Bar-Haim et al., 2007; Dudeney et al., 2015). When examining moderators for maintenance of attention, anxiety subtype was found to significantly moderate findings, with results demonstrating that during free-viewing tasks, individuals with specific phobia had decreased maintenance on threatening stimuli relative to controls, while results were more mixed for the other subtypes. Therefore, although it would be helpful to know if there was specificity in attention bias for these sample-related variables, previous reviews have not offered much evidence that these variables affect attention bias distinctively, except for anxiety subtype.

Age of the sample may be another important sample-related moderator, particularly when reviewing child studies in comparison to adult studies. The meta-analysis of adult and child studies did not find evidence for differences in attention bias when comparing child and adult samples (Bar-Haim et al., 2007); however, in the meta-analysis of child papers, age was found to be a significant moderator, such that attention bias differences between the anxious and control samples increased as the mean age of the sample increased (Dudeney et al., 2015). Therefore, age may need to be examined more narrowly than simply comparing categories of adult and child studies, or age may be an important sample variable to consider only up to adulthood.

5.1.1.5. Task characteristics. When reviewing anxiety-related attention bias studies, there are certain between and within-task characteristics that have been commonly examined as potential moderators of findings. Task features that have been subject to investigation include type of stimuli (word vs. picture), stimulus presentation time, and indices used to assess attention bias. Type of stimuli and stimuli presentation time has been shown to result in non-significant differences in effect sizes in the meta-analyses examining anxiety-related attention biases in adults and children, meaning that these task characteristics did not appear to affect results significantly (Armstrong & Olatunji, 2012; Bar-Haim et al., 2007; Dudeney et al., 2015). However, a meta-analysis examining stimuli specificity to anxiety subtype, meaning that the stimuli used in the attention tasks "matches" feared stimuli, found a significant effect for panic disorder, but no specificity for social anxiety disorder (Pergamin-Hight, Naim, Bakermans-Kranenburg, van IJzendoorn, & Bar-Haim, 2015). Unfortunately, this meta-analysis did not examine eye-tracking

research, included other RT tasks, such as the Stroop task, and did not examine specificity for separation anxiety disorder or specific phobia.

When comparing tasks, researchers have found no significant differences in effect sizes for between-task effects for primarily reaction time paradigms (Bar-Haim et al., 2007; Dudeney et al., 2015); however, there may be between-task effects in eye-tracking paradigms. In the eye-tracking meta-analysis, which assessed eye-tracking studies during visual search tasks and free-viewing tasks (they included eye-tracking versions of the dot-probe as a free-viewing task), it was found that while both visual search tasks and free-viewing tasks showed support for the vigilance hypothesis, only the visual search task revealed differences in later stages of attention (Armstrong & Olatunji, 2012). The anxious groups were more likely to maintain attention on the threatening stimuli relative to controls in the eye-tracking studies of visual search tasks, and there were no significant between-group effects for the free-viewing paradigms. Given that task differences have accounted for differences in results in adult studies, task characteristics were reviewed in the child literature.

6. Results

6.1. Reaction time studies

Five dot-probe studies using pediatric samples were reviewed examining early and late stages of attention biases by using two stimulus presentation times (see Table 2). Short stimulus times ranged from 200-500 ms, and long presentation times ranged from 1250 to 2000 ms. Three studies used clinical samples and two used analogue samples. Two of the clinical samples included a mixture of anxiety subtypes as a primary anxiety diagnoses and the other used a fear disorder group (separation anxiety disorder (SepAD), SocAD, SP, and agoraphobia) and a distress disorder group (GAD, PTSD, and depression).

Overall, three studies found evidence for vigilance in pediatric anxious samples (Pérez-Edgar et al., 2010; Price, Siegle et al., 2014; Waters, Kokkoris, Mogg, Bradley, & Pine, 2010), and one study found distress disorders (GAD, PTSD, and depression) to be more vigilant compared to the control samples (Salum et al., 2013). When including later stages of attention, only one study found marginal evidence for the vigilance-avoidance pattern of attention (Price, Siegle et al., 2014). Other studies found evidence for vigilance followed by increased maintenance on threatening stimuli in anxious samples (Waters et al., 2010) and another found distress disorders compared to control samples to follow that similar attentional pattern (Salum et al., 2013). Fear-disorders, on the other hand, displayed avoidance at both initial and later stages of attention (Salum et al., 2013). Given the inconsistency of findings, no clear patterns emerged across the five studies, except that the majority of the studies found some evidence for increased vigilance for threatening stimuli in the anxious participants relative to control participants.

6.1.1. Sample characteristics

The two studies that used a subclinical anxious sample found the subclinically anxious samples to be vigilant relative to controls (see Table 2); however, it should be noted that these studies used absolute comparisons (bias score significantly different from zero) and not relative comparisons (i.e., anxious samples were not significantly different from the control group or the low behavioral inhibition group) (Pérez-Edgar et al., 2010; Waters et al., 2010). The analogue samples appeared to more robustly find evidence for vigilance in the anxious samples compared to the clinical samples. The studies with clinical groups found either only marginally significant evidence for vigilance in anxious samples (Price, Kuckertz et al., 2014; Price, Siegle et al., 2014), found vigilance in both samples (Price et al., 2013), or used unusual groupings of clinical groups that found opposite results depending on the diagnosis (Salum et al., 2013).

Table 2
Child Dot-Probe Studies: Summary of Task and Sample Characteristics and Findings.

Study	Anx (n)	Con (n)	Anx group	Age range	Anx mAge	Con mAge	Stim	Stim Time 1 (ms)	Stim Time 2 (ms)	Evidence for Initial Orienting	Evidence for Later Attention
Pérez-Edgar et al. (2010)	115 median split		Behavioral inhibition	N/A	15.0 overall		Faces	500	1500	Anxious vigilant	No findings
Price, Kuckertz et al. (2014) and Price, Siegle et al. (2014)	90	31	Clinical-Mix	9–13	10.6	10.9	Faces	200	2000	Anxious vigilant (marginally)	Anxious avoidant (marginally)
Price et al. (2013)	74	20	Clinical-Mix	9–13	10.6	10.5	Faces	200	2000	Both groups vigilant	Both groups maintain attention on threat
Salum et al. (2013)	86 FD/ 66 DD	1411	Clinical- FD & DD	6–12	9.6 FD/ 10.3 DD	9.8	Faces	500	1250	FD with high symptoms avoidant; DD with high symptoms & controls vigilant	FD with high symptoms avoidant; DD with high symptoms & controls maintain attention
Waters et al. (2010)	25	25	Analogue-GAD	9–12	N/A	N/A	Faces	500	1250	Anxious vigilant	Anxious maintain attention

Note: FD = Fear Disorders; DD = Distress Disorders; GAD = generalized anxiety disorder; No findings = no significant between-group differences.

6.1.2. Task characteristics

Reaction time papers ranged in their stimulus presentations and all papers used faces as the stimuli. No consistent differences emerged when comparing the differing presentation times (i.e., 200 ms vs. 500 ms; 1250 ms vs. 1500 ms).

6.1.3. Summary of child reaction-time research

Overall, there was more support for vigilance of attention in anxious samples compared to control samples, but equivalently limited support for the vigilance-avoidance model and for the vigilance followed by maintenance model of attention for anxious children. No clear pattern of developmental differences emerged, nor did differences in tasks or samples that explained discrepancies in findings.

6.2. Eye-tracking research

Nine studies of youth compared attention bias in anxious and control participants using eye-tracking methodology and met criteria for the review. However, one article (that focused primarily on sleep effects on attention bias) by Ricketts et al. (2018) used the same sample and paradigm as the Price et al. (2013) article. Therefore, to avoid redundancies, the article by Ricketts et al. (2018) was excluded from the results and table, leaving eight total studies (see Table 3). Six studies were free-viewing paradigms, and two studies assessed eye-tracking during the dot-probe task. When examining only the initial stage of attention, all but one study (Shechner et al., 2013) found no significant differences between-groups, during longer stimulus presentation times (> 500 ms). In later stages of attention, all but two studies failed to find differences between-groups (In-Albon, Kossowsky, & Schneider, 2010; Shechner et al., 2015). See Table 4 for a summary of support for the various models across all child studies.

6.2.1. Developmental differences

Beginning early in development, infants as young as 5-months-old display a visual preference for threatening stimuli, spending longer time fixating on threatening stimuli, such as angry faces and snake stimuli faces compared to positive stimuli, such as happy faces and flower stimuli (Leppänen, Cataldo, Enlow, & Nelson, 2018; LoBue & DeLoache, 2010; Peltola, Leppänen, Mäki, & Hietanen, 2009). Children between the ages of 9 and 48 months have been shown to display a preference for emotional faces in general (angry and happy faces compared to neutral faces) on eye-tracking versions of the dot-probe task (Burris, Barry-Anwar, & Rivera, 2017; Pérez-Edgar et al., 2017). Differences in negative temperament, which has been considered a risk-factor for the development of anxiety disorders (Fox & Pine, 2012), was not shown to significantly impact time spent dwelling on threatening faces (Burris et al., 2017; Pérez-Edgar et al., 2017); however, latency to looking at the threatening face and probability of first fixation on threatening face were not reported in these studies, which prevents the assessment of vigilance.

When examining the vigilance model in anxious and healthy samples, there appeared to be only limited support for theories that suggest that all youth display vigilance early in life, and later anxious samples retain this vigilant pattern, while youth without anxiety do not. This conclusion is inconsistent with the theoretical perspective of some previous reviews (Field & Lester, 2010; Kindt & Van Den Hout, 2001), but consistent with another by Waters and Craske (2016), which also did not find a clear pattern of results across development. The youngest sample of anxious and non-anxious children was a sample of 3-4-year-olds, who completed a free-viewing task of paired threatening-neutral stimuli (Dodd et al., 2015). Dodd et al. (2015) found that both the anxious and non-anxious group were vigilant to threat, with no significant between-group differences. In another paired emotional face free-viewing task, there was support for vigilance in both child groups (aged 7–11) and adolescent groups (aged 12–17); however, anxious adolescents were more avoidant at initial stages of attention during the short time period (500 ms) (Gamble & Rapee, 2010). In studies that had samples that ranged from childhood to early adolescence (e.g., 8–13 year olds), some papers found that both groups displayed vigilance patterns of attention (Seefeldt, Krämer, Tuschen-Caffier, & Heinrichs, 2014) and yet others found no evidence for vigilance in either group (In-Albon et al., 2010; Price et al., 2013). In studies with large age ranges (i.e., 8–17), no patterns emerged. In sum, there was no clear evidence for developmental differences in initial orienting. No patterns emerged at all when examining later stages of attention.

6.2.2. Sample characteristics

As seen in Table 3, all eye-tracking samples used clinical samples, eliminating the possibility to make comparisons between clinical and analogue samples. While most studies (5) examined anxious populations included multiple types of primary anxiety diagnoses (e.g., GAD, SepAD, SocAD), two papers examined SocAD disorder as a primary anxiety diagnosis and one used a sample of SepAD as a primary diagnosis (note that these samples also had comorbid anxiety diagnoses). In-Albon et al. (2010) used separation-specific stimuli and reported support for the vigilance-avoidance model; however, this study only found vigilance to occur after 1000 ms had already elapsed (initial orienting is thought to occur before 1000 ms (Armstrong & Olatunji, 2012)) and also found that both groups were less likely to first fixate on the threatening picture initially. In the studies comparing SocAD participants to control participants, the researchers found no group differences; however, they did find completely opposite evidence for vigilance in both groups, with one study finding both groups to be vigilant to threat (Seefeldt et al., 2014) and the other finding that both groups displayed avoidance in initial orienting (Schmidtendorf, Wiedau, Asbrand, Tuschen-Caffier, & Heinrichs, 2017). Both papers examining groups with SocAD found no evidence of bias at later stages of attention in both groups. Overall, the lack of papers examining anxiety subtypes makes it impossible to draw any conclusions about anxiety subtype.

6.2.3. Task characteristics

While some eye-tracking papers had participants complete the dot-probe task at the same time, all papers either had paired stimuli or three pictures shown at the same time. Eye-tracking papers had stimulus presentation times ranging from 500 ms to 10,000 ms. No patterns emerged when comparing stimulus presentation times or index used to measure attention biases.

6.2.4. Summary of findings

When taking into account the infant studies, there appears to be a general, consistent preference for negative stimuli before the age of four, with evidence for initial orienting and also increased maintenance of attention on negative stimuli using eye-tracking studies. Research on later childhood and research with wide-age ranges mostly showed no between-group differences. Sample and task-related variables did not appear to affect the pattern of results.

7. Discussion

7.1. Is the vigilance-avoidance model supported in the literature?

In reaction time studies (see Table 2), most articles supported the vigilance model of attention and no study supported the vigilance-avoidance model. In eye-tracking studies (see Table 3), almost all studies failed to find significant differences between-groups for both initial and later attention. While one eye-tracking study in children argued that findings support a vigilant-avoidant pattern in a sample of clinical SepAD (In-Albon et al., 2010), in fact the authors only found the vigilant pattern after 1000 ms, which is after researchers consider initial orienting to occur (Armstrong & Olatunji, 2012). The summary of support for all theoretical models is synthesized in Table 4, which shows that the vigilant-avoidant model is not supported in the current

Table 3
Child Eye-tracking Studies: Summary of Task and Sample Characteristics and Findings.

Study	Anx (n)	Con (n)	Anx group	Age range	Anx mAge	Con mAge	Task	Stim times (ms)	Stim	Index of initial orienting	Index of later attention	Evidence for initial orienting	Evidence for later attention
Dodd et al. (2015)	37	46	Clinical-Mixed	3–4 years	4.0	4.0	Free-viewing	1250	Faces	Probability of initial fixation	Length of initial fixation & dwell time	Both groups vigilant	Both maintained (dwell time)
Gamble and Rapee (2010)	49	43	Clinical-Mix	7–11; 12–17	9.8; 14.0	10.6; 13.7	Free-viewing	500; 3000	Faces	Probability of initial fixation & 1000 ms epochs	1000 ms epochs	Anxious adolescents avoidant at 500 ms; Both groups vigilant for first 2000 ms in 3000 ms trials	Both groups avoidant in last 1000 ms in 3000 ms trials
In-Albon et al. (2010)	23	17	Clinical Anxiety-SepAD	8–13 years	9.9	10.3	Free-viewing	4000	Separation-reuniting pictures	Probability of initial fixation & 500 ms epochs	500 ms epochs	Both groups avoidant (probability)	Anxious vigilant (1000–2000 ms); Anxious avoidant (3000–4000 ms)
Price et al. (2013)	74	20	Clinical-Mix	9–13 years	10.6	10.5	Dot-probe	2000	Faces	Probability of initial fixation & 500 ms epochs	500 ms epochs	Both groups avoidant (epochs)	Both groups avoidant
Seefeldt et al. (2014)	30	42	Clinical-SocAD	8–12 years	9.9	9.9	Dot-probe	3000	Faces	Probability of initial fixation & 500 ms epochs	500 ms epochs	Both groups vigilant (epochs)	No findings
Schmidtendorf et al. (2017)	37	42	Clinical-SocAD	9–13years	11.4	11.5	Free-viewing	5000 ms	Faces	Probability of initial fixation	500 ms epochs	Both groups avoidant	No findings
Shechner et al. (2013)	18	15	Clinical-Mix	8–17 years	12.3	14.3	Free-viewing	10000 ms	Faces	Probability of initial fixation & Latency of initial fixation	500 ms epochs	Anxious vigilant (both indices)	No findings
Shechner, et al. (2015)	19	26	Clinical-Mix	8–17 years	12.1	13.0	Free-viewing	5000	2 Threatening & 1 Neutral Pictures	Probability of initial fixation & Latency of initial fixation	Cumulative dwell time	No findings	Anxious avoidant

Note: GAD = generalized anxiety disorder; SocAD = social anxiety disorder; SepAD = separation anxiety disorder; No findings = no significant between-group differences.

Table 4
Summary of Support for Theoretical Models Across All Child Studies.

Models	Both groups displayed pattern (# of studies out of 12)	Anxious displayed pattern compared to controls (# of studies out of 12)
Initial vigilance	4	3
Initial avoidance	3	0
Later maintenance	2	1
Later avoidance	2	2
Vigilance-avoidance	1	0
Vigilance-maintenance	2	1

Note. Salum et al. (2013) paper was not included because found differing results for Distress Disorders compared to Fear Disorders.

literature in children. However, additional research is necessary to definitively reject this model for anxious youth.

7.2. Would a different model support the empirical findings better?

Given the very limited support for the vigilance-avoidance model of attention, a natural subsequent question is if there is a model of attention that better fits the data that also accounts for two stages of attention. There appears to be equivalent support for a different, two-stage model of attention that shows heightened vigilance for threat and greater maintenance of attention of threat, which is sometimes interpreted as difficulty in disengaging attention. Only one study found support for a "vigilance-maintenance" pattern of attention. Overall, the most evidence gathered from this literature supports the vigilance model in anxious youth.

7.3. Is there a developmental pattern of results?

As reviewed earlier, Field and Lester (2010) offered a conceptualization for how biases in information processing can develop, which includes the moderation model. This model proposes that all infants have information processes towards threat, but these biases are reduced over the course of development as a result of many individual factors, including anxiety.

Although longitudinal research would best be able to identify developmental trajectories, the present review compared age groups. Given infant and preschool age results (Dodd et al., 2015; LoBue & DeLoache, 2010; Peltola et al., 2009), which found evidence for increased vigilance for threatening stimuli for all youth (e.g., no significant between-group differences in biases based on temperament or anxiety), there is some support for the moderation model of development, given that it appears all youth have biases for threat present at an early age. However, the moderation model suggests a divergence between groups based on a number of individual factors, such as anxiety.

This review suggests there is mixed support for a developmental progression in which anxious and healthy samples eventually diverge, as the moderation model would predict. In reaction time tasks, it appeared that there was strong evidence for vigilance in threat in anxious but not control samples, but there did not appear to be any pattern based on age. When examining eye-tracking studies, there was no clear support for increased vigilance in anxious samples compared to healthy samples and no clear divisions by age. The majority of eye-tracking tasks (5 of 8) in fact found no difference in attentional patterns when comparing groups at any attentional stage. One reason for divergent findings between methodologies could be that the dot-probe task may be more sensitive to finding differences between groups, perhaps because RT tasks also provide an index of covert attention, while eye-tracking tasks measure overt attention. Another possibility is that current eye-tracking tasks are not suited to probe for differences in attention between-groups.

7.4. Recommendations for future studies

Overall, more research should be conducted that explicitly quantifies attention at multiple time points, particularly in child populations in order to conclusively determine if attentional models are supported in anxious youth. The limited amount of studies that do allow for the assessment of the time course of attention signals a major limitation in the attention bias field and a critical area for further research. Furthermore, inclusion of trials that explicitly assess for difficulty in disengaging attention would help distinguish attention maintenance from difficulty disengaging. Further research with these considerations would allow for the necessary measurement of the time course of attention in anxious relative to nonanxious youth that can be used to inform interventions.

Considering that eye-tracking paradigms less consistently found evidence for attention bias differences in child samples and less consistently found evidence for vigilance in anxious relative to control samples compared to reaction-time tasks, eye-tracking methodology may need to be refined in order to detect attention bias differences between-groups. The majority of eye-tracking paradigms used to measure the time course of attention are free-viewing tasks with paired stimuli, which is not characteristic of everyday life. Visual search tasks offer an improvement in offering realistic scenarios, by having individuals view multiple pictures simultaneously. A particularly ecologically valid version of this task was put forth by Pflugshaupt et al. (2005), who embedded spiders in everyday scenes (e.g., a bathroom), and compared individuals with spider-phobia to controls. Additionally, Chen, Clarke, MacLeod, Hicke, and Guastella (2016) compared individuals with SocAD to controls during a speech task in front of a pre-recorded audience, which increased the real-world applicability of their findings. Improvement in the ecological validity of paradigms may better highlight differences in anxious and nonanxious youth; however, this hypothesis has yet to be examined.

Another limitation in eye-tracking tasks is the variation in how vigilance and later maintenance of attention is measured. When measuring initial vigilance, some studies use epoch indices (measuring dwell time or number of fixations in time bins), while others measure probability of initial fixation or latency to fixate on stimuli. Epoch-related variables may not be a direct measure of initial orienting, because multiple fixations can occur in the time bins used (e.g., 500 ms). However, one benefit to epoch indices of initial orienting is that epoch variables may be more similar variable to RT variables, which also have the same limitation, and thus may be more comparable. Additionally, results during later stages of attention can be difficult to interpret in free-viewing tasks. Increased dwell time on threatening stimuli is sometimes interpreted as difficulty in disengaging (rather than just increased maintenance), despite there being no experimental manipulation that creates a need to shift attention. Visual search studies offer an improvement in this consideration, because they require participants to search for a specific target.

In summary, more research is needed that examines attention at multiple time points. Additionally, eye-tracking studies can be improved to increase ecological validity and ease of interpretation of results. Studies have begun to improve ecological validity of paradigms; however, research is needed to uncover if these paradigms offer more advantages compared to more classic paradigms.

7.5. Treatment implications

7.5.1. Attentional Bias modification treatment

Over thirty years of research examining attention biases in anxious samples have led researchers to develop interventions based on the same experimental paradigms used to measure attention biases, such as the dot-probe task and the visual-search task (Hallion & Ruscio, 2011). Most ABM interventions are based on the dot-probe task (MacLeod et al., 1986), although the visual search paradigm (e.g., Dandeneau,

Baldwin, Baccus, Sakellaropoulo, & Pruessner, 2007) and emotional-spatial cueing task (e.g., Bar-Haim, Morag, & Glickman, 2011) have also been adapted. Studies that are designed to reduce attention bias toward threat increase the frequency with which the probe replaces the neutral stimulus, implicitly training attention away from the threatening stimulus.

Nine recent meta-analyses have compiled data in order to test the efficaciousness of ABM interventions in reducing anxiety and a systematic review was conducted examining these meta-analyses (Jones & Sharpe, 2017). ABM was found to have an anxiolytic effect in most papers, with effect sizes ranging from small to large effects (ES = 0.13-0.74); however, publication bias could have affected the magnitude of effects (Jones & Sharpe, 2017). Changes in attention bias were found to be significantly associated with changes in anxiety symptoms, finding greater reduction in anxiety symptoms for studies that found greater reduction in attention bias (Mogoaşe et al., 2014).

Developmental differences have been considered in meta-analyses of ABM, generally by examining age as a moderator of findings. Two meta-analytic reviews of ABM found age to have a significant effect on the efficacy of ABM interventions, finding that ABM was more effective in reducing anxiety symptoms in younger samples (Mogoaşe et al., 2014; Price, Wallace et al., 2016). In contradiction, the meta-analysis that only examined children (Cristea, Mogoaşe, David, & Cuijpers, 2015) did not find a significant effect size in cognitive bias modification interventions (g = 0.17); however, this meta-analysis used cognitive bias interventions other than ABM and did not report results when only analyzing anxiety studies. Additionally, a systematic review of pediatric anxiety ABM interventions found that the pattern of results generally demonstrated evidence for ABM in reducing anxiety, finding eight out of the ten papers reviewed demonstrating ABM's anxiolytic effects (Lowther & Newman, 2014). Thus, ABM interventions generally show positive outcomes in anxiety outcomes and actually may be more efficacious in younger samples.

7.5.1.1. Implications of current review in ABM interventions. A critical limitation of ABM interventions is that it is unclear what mechanism of attention ABM is targeting. The vast majority of ABM interventions are reconfigured versions of the dot-probe task, which is commonly criticized for not delineating the components of attention (Cisler & Koster, 2010; Fox et al., 2001). Thus, are most ABM interventions training attention away from the threatening stimuli? Or, are ABM interventions instead training faster disengagement away from threatening stimulus? Consequently, it is important to better understand anxious individuals' pattern of attention—not only at the initial stages of attention, but at later stages of attention as well, so that interventions can be modified to properly address problematic patterns of attention. Given the conflicting pattern of results found in this review, more research is needed to systematically evaluate under which conditions and variables attention biases are found most reliably so that ABM interventions can properly address these problematic biases.

8. Conclusion

Enduring cognitive models of anxiety posit that negative biases in information processing are implicated in the etiology, maintenance, and recurrence of anxiety disorders (Beck, 1976). Specifically, the vigilance-avoidance model of attention (Mogg & Bradley, 1998) was proposed to explain anxious individuals' pattern of visual attention and is widely and often referenced. We comprehensively reviewed literature that was capable of testing the vigilance-avoidance model of attention and found that there is currently no systematic evidence for the vigilance-avoidance model of attention among anxious children. We hope that the review provides a valuable synthesis of the work and findings to date, while highlighting the key missing elements for future studies. Future research examining attention biases should employ rigorous methodology that allows for the assessment of the time course of attention and address important methodological limitations such as ecological validity and lack of longitudinal follow-up. If robust moderators of attentional patterns emerge from such studies, e.g., based on time course of attention, sample characteristics, and/or task variables, this may ultimately inform interventions.

Conflicts of interest

This project was supported by NIMH grant R01 MH103241 awarded to Jennifer S. Silk. Rebecca B. Price is supported by NIMH grant K23MH100259.

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