The role of attention bias to threat in anxiety: mechanisms, modulators and open questions ☆

Hadas Okon-Singer

Individuals at risk of developing anxiety and those with (sub-) clinical anxiety have robust attention biases to irrelevant threats, among them facilitated engagement, difficulty in disengaging and later avoidance of threat. These attention biases are thought to be associated with abnormal activation and connectivity in prefrontal-limbic-sensory neural circuits. Attention biases were shown to be related to other processing biases, but more empirical data are needed to better understand the causal role of each processing bias and to develop effective treatments. These attention biases have further been suggested as playing a causal role in anxiety, although mixed findings from attention bias modification studies challenge this contention.

Address
Department of Psychology, University of Haifa, Haifa, Israel

Corresponding author: Okon-Singer, Hadas (hadasos@psy.haifa.ac.il)

Evidence indicates that individuals with anxiety have maladaptive attention biases toward threat, even when the threat is irrelevant. These biases include enhanced vigilance (i.e., faster orienting of attention) during early processing stages subserved by the amygdala and sensory regions; difficulty in disengaging attention away from threat modulated by executive attentional control in prefrontal, cingulate and orbitofrontal regions; and threat avoidance (i.e., preferential shifting of attention to opposite locations, even when the threatening item is no longer present) during late processing stages modulated by prefrontal regulation. These attention biases were suggested to play a causal role in initiating and maintaining anxiety [1,2].

This review focuses on the role played by attention biases to irrelevant threat in anxiety. The review briefly summarizes recent evidence for attention biases among healthy participants, individuals at risk of developing anxiety and individuals with (sub) clinical anxiety. It then discusses possible causal relationships between attention biases and other information-processing biases in anxiety and discusses findings from two common types of attention training: attention bias modification (ABM) and executive attention control. Finally, the review poses open questions and offers suggestions for future studies.

Biased attention toward threat among healthy participants, individuals at risk and individuals with (sub) clinical anxiety

Healthy individuals exhibit facilitated early engagement of attention when confronted with threatening stimuli, as well as difficulty ignoring negative distractors [3,4,5••,6,7•]. Nevertheless, this prioritized attention to negative information among healthy participants is modulated by different factors, including context [8], perceptual [9] and cognitive [10] load, processing type [11], modality [12], distance from threat [13] and interaction between modulating factors [14,15]. Recent findings suggest that low-level sensory features may explain prioritized processing. As a category, task-irrelevant faces attracted more attention than a control stimulus (i.e., a butterfly), possibly due to low-frequency information sufficient for global face processing. Yet contrary to the common view that irrelevant threatening faces are specifically prioritized due to their evolutionary value, irrelevant angry faces attracted no more attention than neutral ones [16].

Populations at high risk of developing anxiety, such as individuals with dispositional negativity (a tendency to feel and express more frequent and severe negative affect and anxiety), demonstrated enhanced attention biases compared to healthy controls. Dispositional negativity is characterized by faster orienting of attention and slower disengagement from distracting threats, as well as enhanced caution and increased alertness in potentially threatening situations. Indirect evidence suggests that dispositional negativity is accompanied by enhanced amygdala activation and abnormal connectivity between the amygdala and dorsolateral prefrontal regions, which may underlie these various attention biases [17].

Individuals with clinical or subclinical levels of anxiety demonstrate robust attention biases to task-irrelevant threats [18,19]. Notebaert *et al.* [20] also showed that attention biases toward threat cues among highly anxious participants are not modulated by the ability to avoid danger. These biases may be due to reduced prefrontal and enhanced limbic and sensory activation in anxiety, reflecting reduced regulatory control over threat vigilance.

In sum, individuals at risk of developing anxiety and those with (sub) clinical anxiety show biased attention to threat, even when irrelevant, while healthy participants show prioritized attention only to task-relevant threat. Attention biases to irrelevant threat may result from abnormal prefrontal-limbic-sensory regulatory circuits.

Relation between attention biases and other information processing biases

Anxiety is characterized by abnormalities in other aspects of information processing, including maladaptive abnormalities in sensory perception of threatening items, atypical memory of negative items, negative interpretation of ambiguous cues and negative expectations regarding the future [2].

To date, most research on biased information processing in anxiety has focused on attention. Furthermore, only a few studies have examined possible relations between different biases. Therefore, although understanding the causal relationships between specific biases in anxiety is important for developing treatments targeting the core causal processes, the existing literature does not allow suggesting a directional model.

A recent review [21] underlines the role of expectation and attentional processes in the prioritized perception of threatening stimuli among healthy individuals. Threat-related cues, compared to neutral cues, result in enhanced activation of sensory, decision-related and attention-related fronto-parietal neurons that enhance perceptual sensitivity and decrease reaction times. Grupe and Nitsche [22] propose that abnormal uncertainty regarding future events among anxious individuals involves increased amygdala activation, yielding increased hyper-vigilance, avoidance and poor control associated with abnormal activation in sensory, prefrontal, striatal and limbic regions.

Recent findings suggest that expectancy is not always related to faster threat perception. In one study, participants with high trait anxiety exhibited higher perceptual sensitivity in the presence of relevant threat (i.e., electric shock), but worse performance in the absence of threat [23]. Another study demonstrated that threat perception is not always modulated by anticipation or anxiety. When participants were shown a visual search array preceded by anticipatory cues and were asked to report a task-relevant deviant bird or spider, the anticipatory cues predicted reactions to neutral bird targets but had no effect on reactions to threatening spider targets [24]. These results were found among participants with both high and low fear of spiders, in line with biological preparedness. Taken together, these results suggest that the influence of biased expectancies on attention and perception in anxiety is modulated by various factors. More data are needed to draw firm conclusions.

Attention biases may be related to another type of perception bias. Participants with extreme spider phobia perceived the actual size of spiders as bigger than did less fearful controls [25]. A similar perception bias was lowered by exposure to spiders [26]. In line with these findings, new event-related potentials (ERPs) research indicates that emotions influence very early ERP components in visual areas [27]. Sensory biases occur during early processing stages, similar to enhanced vigilance and delayed disengagement of attention. More research is needed to better understand the relation between attention and size perception biases.

In sum, attention, expectancy and perception biases are evident in anxiety, but only a few studies have investigated their causal relationships, with inconclusive findings. More data are needed to understand these causal relations and underlying prefrontal-limbic-sensory abnormalities.

Insights from attention training

Many studies employ cognitive training, which is thought to modify attention biases. This type of research seeks to better understand the causal role of attention in anxiety and to alleviate clinical symptoms. Yet the results of such interventions are mixed [28•]. In ABM techniques, two stimuli — commonly neutral and threatening — are presented in parallel. Participants are trained to focus their attention on neutral rather than threatening stimuli. Threat vigilance/avoidance is calculated by comparing reaction times to targets appearing in locations previously occupied by threatening versus neutral cues. Analysis of pooled patient-level datasets from highly anxious individuals demonstrated ABM's modest but significant effect on remission and attention bias [29]. ABM's effectiveness was limited to patients younger than 37, patients assessed by clinicians and training conducted in laboratory settings. Considering these limitations, the authors suggest developing more engaging ABM paradigms and/or combining ABM with other treatments. Another review of ABM in highly anxious individuals [30••] underscores the disappointing results of threat-avoidance ABM, especially if the training did not take place in the lab. In addition, anxiolytic effects were not related to alterations in attention bias following ABM. The fact that fear and overt threat behavior may not always be 'synchronized',