Information processing biases in generalised anxiety disorder

Sarra Hayes and Colette R. Hirsch

Institute of Psychiatry, King’s College London.

Abstract

Generalised anxiety disorder (GAD) is characterised by the repeated experience of chronic, excessive, and uncontrollable worry regarding a range of different topics. Such individuals report particular difficulty controlling worry once it is initiated. Information processing models of GAD propose that the way in which anxious individuals process threatening information has a causal role in initiating and maintaining worry. There is substantial evidence that individuals with GAD and high levels of worry and anxiety demonstrate a threatening attentional bias, whereby they preferentially attend to threatening information in their environment. There is also substantial evidence that individuals with GAD demonstrate a threatening interpretive bias, in which they favour the threatening meanings of emotionally ambiguous events or information. Recent research has indicated that it may be possible to train high anxious individuals to adopt more benign attentional and interpretive biases, and furthermore, that this may cause their level of anxiety and worry to decrease. There is far less evidence that anxious individuals show enhanced memory for threatening information. However, high levels of anxiety and worry have been associated with reduced working memory capacity (a limited capacity store needed to engage in different tasks and switch between tasks), due to worry taking up limited resources. This may make it more difficult for individuals with GAD to redirect their thoughts away from worry and onto more benign topics, therefore causing their worry to persist.

Keywords: generalised anxiety disorder; information processing biases; cognitive biases; worry; attention; interpretation; memory; working memory.
Introduction
Generalised anxiety disorder (GAD) is a chronic and disabling disorder often resulting in severe cognitive, occupational, and social dysfunction. The key defining feature of GAD is worry concerning a range of different topics. Worry has been defined as “a chain of thoughts and images, negatively affect-laden and relatively uncontrollable” (1). Whereas proneness to worry varies continuously across the normal population, individuals with GAD are often distinguished from individuals with non-pathological worry by their reported uncontrollability of worry once it is initiated (1). Difficulty controlling worry often results in prolonged bouts of worry that are difficult to switch off, which may cause the sufferer significant distress and impair functioning. Research provides strong support for a dimensional structure of worry, with normal and pathological worry representing opposite ends of a continuum rather than discrete constructs (2). As such, it is useful to examine studies that have compared self-labelled low versus high worriers, as well as studies that have compared a clinical population of GAD clients with non-anxious controls.

Information processing in GAD
Research on worry in both non-clinical and GAD populations have revealed that worry appears to be a primarily verbal/linguistic (as opposed to imaginal) activity (3). Several researchers have reported an association between worry and reports of thoughts versus images (4; 5; 6). An important aspect of GAD and high anxious individuals is the way in which they process threatening information. Information processing models of GAD propose that susceptibility to anxiety is due to the operation of selective processing biases (i.e. a systematic tendency to preferentially process a particular class of information) within the cognitive system. Such accounts consider anxiety to result from the tendency to preferentially attend to threatening information, to draw threatening inferences under conditions of ambiguity, and/or to preferentially retrieve threatening information from memory. It has been suggested that such biases may play a causal role in the persistence of worry in GAD. Information processing accounts of GAD are critical in providing more complete
cognitive behavioural therapy (CBT) models of the disorder. Greater understanding of the mechanisms that maintain worry in GAD may lead to more effective treatments designed to target uncontrollable worry.

**Attention**

Attentional bias refers to the systematic tendency to attend to a particular class of stimuli in one’s environment (e.g., certain events or information). There is now a wealth of evidence to demonstrate that anxiety is associated with an attentional bias that operates to favour the processing of emotionally threatening information when threat and non-threat information is presented (7). Such an attentional bias has been observed in both clinical GAD clients, as well as non-clinical individuals who report high levels of worry and anxiety. Researchers have also reported data that support the presence of an anxiety-linked attentional bias on a range of different cognitive-experimental tasks.

**Emotional Stroop task**

A task that has been widely used to study attentional bias is the emotional Stroop paradigm. In this task, individuals are presented with threatening words (e.g., disease, failure) and non-threatening words (e.g., holiday, contented), displayed in different ink colours, and required to rapidly name the colour of each word while ignoring its content. Using this task, research found that GAD clients were significantly slower to colour-name threat-related words, particularly those associated with their reported worries (8). These results suggest that anxious clients are disrupted in the colour-naming task because their attention is consumed by the threatening word content. However, a common criticism of this paradigm is that various cognitive mechanisms other than selective attention may account for slower colour-naming latencies. For example, longer reaction times may reflect attempts by the individual to suppress the threatening meaning of the word, and if so, the Stroop task would be assessing cognitive avoidance rather than attention (9).
Dot-probe task

Attentional bias has also been demonstrated using the more methodologically sophisticated dot-probe paradigm. In this task, participants are simultaneously shown word pairs that consist of one threatening and one non-threatening word. Following this word display, a dot is then presented in the previous location of one of the words. Participants are asked to detect the dot by pressing a button as quickly as possible. This task is illustrated in Figure 1. Using this paradigm, research found that GAD clients demonstrated significantly faster reaction times to dots that replaced threatening versus neutral words (10), see Figure 2. These results indicate that anxious individuals are preferentially attending to threat relative to non-threat stimuli, consistent with an attentional vigilance for threat.

Insert Figures 1 & 2 Here

While studies employing the dot-probe paradigm have traditionally used verbal stimuli, in the form of threat and non-threat words, effects have also been demonstrated on this task using emotional faces (e.g., angry and happy facial expressions; 11).

Attentional disengagement studies

While there is substantial evidence to suggest that GAD and high levels of anxiety are associated with an attentional bias towards threatening stimuli, what is less clear is whether this bias occurs because such individuals are faster to detect threatening information (engagement), or because they experience greater difficulty shifting their attention away from threat (disengagement). Recent research has investigated this issue using a cued-attention task in which participants are required to detect visual targets (e.g., small shapes) in either the same or a different location as a previously presented threatening or neutral stimulus. In contrast to the dot-probe task, this task involves presenting only one stimulus on the screen at the one time. Studies using this paradigm have demonstrated that high anxious people were not significantly faster
than non-anxious people to detect targets in the same location as the threat than the neutral stimulus. However, when the target was presented in the opposite location to the threat stimulus, anxious people were significantly slower to respond, indicating a tendency to dwell their attention on threat-related material (12; 13). Therefore, attentional bias in anxiety may principally reflect difficulty shifting attention away from threat-related stimuli.

The causal role of attention bias in GAD
Recent cognitive theories have proposed that the operation of an attentional bias towards threat material in GAD may play a critical role in the etiology and maintenance of the disorder (14). Attentional bias to threat cues in the environment may result in increased perception of danger and thus more frequent or intense experiences of anxiety and worry (15). Consistent with this account, it has been shown that following cognitive behavioural therapy (CBT) for GAD, attentional bias for threat is successfully reduced (16).

It is important to recognise, however, that an association between attentional bias for threatening stimuli and high anxiety does not necessarily indicate that such a bias causally contributes to anxiety, since attentional bias may be an incidental or secondary consequence of anxiety and worry. In order to determine causality, it is first necessary to experimentally manipulate attentional bias, and then examine the impact of this manipulation on anxiety. Recent research has demonstrated that attentional biases can be manipulated by single session experimental training procedures in normal volunteers. One such study used a modified dot-probe task to experimentally induce different attentional responses to emotional stimuli (17). In this task, following each threat-neutral word pair that was presented, a to-be-detected visual target either consistently appeared in the location of the neutral word (benign training) or the threat word (threat training). This paradigm therefore trained attention to be directed either away from or towards threat cues. Following training, participants took part in a stress test in which they had to complete difficult
anagrams, and then their anxiety was assessed. Those trained to attend to threat stimuli reported greater anxiety than those trained to attend to neutral stimuli. This suggests that a threatening attentional bias can fuel anxiety. Such findings carry potentially important therapeutic implications for GAD: if anxious individuals can be trained to adopt a more benign attentional bias, this may decrease their anxiety and worry.

**Interpretation**
In addition to being associated with an attentional bias towards threat, GAD, worry, and anxiety have been shown to be associated with greater access to threatening meanings of emotionally ambiguous information and events.

**Recognition memory task**
In a study using a recognition memory paradigm, current and recovered GAD clients were compared with a group of non-anxious controls (18). In this study participants listened to a series of ambiguous sentences that could be interpreted in either a threatening or non-threatening manner (e.g., “Your boss calls you to their office to discuss the quality of your recent work”). They were then presented with alternative disambiguated versions of the sentences (e.g., “Your boss calls you to their office to say your work is not up to standard” for the threat version; and “Your boss calls you to their office to congratulate you on your work” for the non-threat version), with the sentences being rated for similarity to the original statement. Participants were also presented with threat and non-threat distractor sentences that were not related to the original meaning (e.g., “Your boss calls you to their office to ask why you are not getting on with your colleagues” for the threat distractor; and “Your boss calls you to their office to offer you a pay rise” for the non-threat distractor). Non-anxious controls were more likely to endorse the benign interpretations of the sentences as having the same meaning as the original ambiguous sentence they had heard, while anxious clients endorsed both threat and benign interpretations to a similar extent.
Correct rejections of threatening and benign distractors showed that these group differences reflected variations in how the original ambiguity had been encoded.

**Homophone spelling task**
Using a different paradigm approach, another study aurally presented a series of threat-related homophones (19). These are words that sound the same but have two different meanings, one threat and one non-threat meaning (e.g., “slay/sleigh”). This study found that GAD clients were more likely to produce the threat-related spelling of such homophones than were non-anxious controls, while individuals in remission from GAD were intermediate in this respect. This suggests that people with GAD have a threatening interpretation bias.

**Priming tasks**
Interpretation bias has also been assessed using priming tasks. The idea behind priming studies is that the processing of a target word (e.g., tree) is facilitated when a related word has been processed shortly before its presentation (e.g., forest). In a study utilising a priming methodology, participants were presented with a series of threat-related homographs (20). These are words that are spelled the same but have two possible meanings, one threat and one non-threat meaning (e.g., ‘stroke’ could either be interpreted as a medical illness, or to pat a cat). In this particular study, each homograph prime was immediately followed by either a target word associated with one of the prime meanings (e.g., ‘heart’ or ‘cat’), or a non-word letter string (e.g., ‘alap’). Participants were asked to silently read the first word that came on screen (priming word), and then respond as quickly as possible whether the following stimulus was a word or not. High anxious participants were faster to indicate that the letter string was a real word when it was associated with the threatening meaning rather than the non-threatening meaning of the ambiguous prime, while low anxious participants displayed the opposite effect. Such results indicate that high anxious individuals interpret threatening ambiguous words in a negative manner.
Similar effects have also been found in priming studies where ambiguous sentences (rather than words) are used as stimuli. In one such study (21), participants were required to read aloud ambiguous sentences (e.g., “The two men completed the service and filled in the hole”), followed by another sentence that was consistent with a threat meaning (e.g., “The funeral was soon finished”) or a non-threat meaning (e.g., “The repair was soon finished”). High anxious participants displayed significantly faster reading times for continuation sentences that were threat-related relative to non-threat-related, indicating they had interpreted the ambiguous scenario in a threatening manner.

The casual role of interpretive bias in GAD

As highlighted previously, it is possible that the habitual interpretation of ambiguous events in a threatening manner is simply an epiphenomenon, rather than a causal factor in the maintenance of anxiety and worry in GAD. In order to determine causality, interpretative bias must first be manipulated, and then its impact on anxiety and worry assessed. Recent research has examined whether threatening interpretive biases commonly found in GAD clients and high anxious individuals can be induced by training in non-anxious controls (22). In this study, participants received repeated exposure to either threat or neutral meanings of threat-related homographs. Following training, participants that had received repeated exposure to neutral resolutions of ambiguous words were faster to access words associated with the non-threat meanings of a new set of homographs. This research thus demonstrates that it is possible to train a more benign interpretive bias in non-anxious individuals.

In addition to the aim of determining whether the way in which people interpret emotionally ambiguous events can be altered, another study has also looked at testing the causal hypothesis that changes in emotional interpretations can lead to changes in anxiety levels (23). In this study, non-anxious individuals were repeatedly shown a series of emotionally ambiguous scenarios which were resolved in either a consistently positive manner (positive training) or a consistently negative manner (negative training). In a subsequent recognition test, a benign interpretation bias was
evident for the benign trained group, and a more threatening bias for the threat trained group. This study again demonstrated that it is possible to train interpretation bias. In addition, it was found that anxious mood state increased in those who received negative training, and decreased in those who received positive training. This finding suggests that the manipulation of interpretive bias serves to modify anxiety reactivity.

Previous training research has been confined to non-anxious populations. It is important to establish whether interpretation bias has a causal role in maintaining worry in GAD. Recent research has demonstrated that training high worriers to consistently access the benign meanings of emotionally ambiguous words and sentence materials effectively reduces worry persistence (24). Such findings indicate that a threatening interpretive bias may play a causal role in maintaining prolonged bouts of worry in high worriers. Furthermore, this study also included a subset of individuals who met criteria for GAD, and this training was also effective in reducing worry in this population. This bodes well for the potential future use of these techniques in helping to treat clients with GAD. See Table 1 for examples of ambiguous sentence materials used in interpretation bias assessment and training studies.

Memory

In contrast to strong evidence that individuals with GAD and high anxiety typically display both an attentional bias favouring the encoding of threatening stimuli and an interpretive bias favouring threatening resolutions of ambiguity, there is substantially less evidence that such individuals show enhanced memory for threatening information (14).

Numerous studies have reported that compared to non-anxious controls, GAD clients show no superior ability to recollect threatening information, whether using free-
recall or recognition measures (25). In fact, in this study GAD clients actually showed a slight memory bias for non-threatening information, correctly recognizing fewer threat words and more non-threat words than non-anxious controls. Further follow-up studies have also failed to discover recall of more threatening information by individuals with GAD, even for self-referent materials (26; 27). On the few occasions anxious participants have shown a memory bias for emotionally negative information, it has been suggested that the effects may be more due to depression than trait anxiety (28).

Implicit memory
Research has postulated that high anxious individuals may be more likely to show enhanced implicit memory (rather than explicit memory) for threatening information. Explicit memory is when people are asked to deliberately recall or recognise certain information, while implicit memory is when peoples’ performance is affected by what they learnt earlier, without them realising such remembering is taking place. In one such study that used an explicit memory test (cued recall; where people are asked to recall as many words as possible) as well as an implicit memory test (word completion; where people are given the first few letters of a word and asked to complete it with the first word that comes to mind), GAD clients showed no explicit memory bias for threat-related words, but did show an enhanced implicit memory bias, producing more threat than non-threat word completions (29). Nevertheless, other studies have failed to replicate such an implicit memory advantage in GAD clients (30; 16). In sum, evidence for a memory bias favouring threatening information in GAD is less compelling than is the evidence for threat-related attentional and interpretive biases in GAD. It has been suggested that this may be because GAD clients actively avoid elaborative processing of threat, and thus have poorer recall of such information (14). See Table 2 for a summary of tasks used to assess information processing biases and the relative evidence for such biases in GAD.
Working Memory
While studies have generally failed to provide support for memory biases for threat-relevant information in GAD, there is evidence to suggest that high levels of anxiety are associated with a reduction in a different type of memory known as working memory capacity (31). Working memory capacity is a limited capacity resource needed to engage in different cognitive tasks, as well as switch between tasks (32). There have been several studies that have investigated the effects of elevated levels of anxiety on working memory capacity. One such study employed a methodology which required people to perform two different tasks at the same time, with one of these tasks varying in difficulty (33). Specifically, participants performed a grammatical reasoning task while at the same time remembering either a string of six different numbers (e.g., 7, 2, 9, 3, 1, 2) or a string of six zeros (e.g., 0, 0, 0, 0, 0, 0). Whilst all participants performed more poorly on the reasoning task when they had to hold a string of different numbers in mind, performance was disproportionately poorer for high anxious compared to low anxious individuals. Theoretical models accounting for such findings have proposed that worry is associated with a restriction in available working memory capacity as worry consumes limited capacity resources (34). As a result, high worriers may be less able to redirect thoughts away from worry and onto non-worry topics than low worriers, resulting in perseverance of worry.

Other studies have also demonstrated that worry utilises working memory resources (35). A recent study has assessed the direct impact of worry on residual working memory capacity in high worriers (36). The task used to assess this was an established random key press task, in which more random performance indicates more residual working memory capacity to be used on other tasks. This random key press task was performed whilst participants thought about either a current worry topic or a positive personally relevant thought topic. High worriers were shown to have more working memory capacity taken up when worrying than when thinking.
about a positive thought topic. In contrast, non-worriers had the same amount of working memory capacity taken up when thinking about a worry or a positive topic. Such findings suggest that high worriers have less residual working memory capacity available when engaging in worry and as such, may have less working memory available to enable them to switch their thinking away from worry onto non-worry topics. The potential role of working memory in the persistence of worry in GAD is illustrated in Figure 3.

Insert Figure 3 Here

**Summary**

In conclusion, there is now substantial evidence to indicate that GAD clients are biased to specifically notice events or information in the environment related to their worry content, and once noticed, experience difficulty shifting their attention away from this information. Subsequently, when they encounter emotionally ambiguous events or information, they are biased to interpret such information in a threatening manner, and have difficulty interpreting it in a positive or non-threatening way. For example, if we consider a person who is experiencing chronic worry regarding the possibility of becoming seriously ill, their attention might first be captured by an illness-related photograph (e.g., a photograph of a hospital) that appears amongst numerous other photographs on a page of a newspaper. Once they have noticed this photograph, they may then find it extremely difficult to drag their attention away. Next they may start to worry about their own health, and wonder if their current cough is going to go away or indicates a more sinister illness. They are then more likely to make the threatening interpretation that they are seriously ill. They will then continue to worry about their health. Next, when they turn the page, they might see an emotionally ambiguous word (e.g., ‘growth’), which they may subsequently interpret in a threatening manner (i.e. cancerous growth). In addition, substantial working memory resources consumed by worry regarding this topic may leave them with fewer resources available to notice and then switch the focus of their attention onto
more benign thoughts, and/or to process alternative non-threatening meanings of this ambiguous information. As a result they would continue to worry about the possibility of falling ill, and the cycle would continue. See Table 3 for a summary of key points raised in this article.

Further Reading

References


Figure 1. Illustration of the dot-probe task trial

- Fixation
- Word pair: Threat, Non-Threat
- Press button as soon as see dot on screen

→ DEATH

→ APRIL

→ *

→ Begin next trial
Figure 2. Dot probe task typical results: Reaction times to probes replacing threat versus non-threat words for Low and High Anxious participants
Table 1. Examples of ambiguous sentence materials used in interpretation bias assessment and training studies (words in brackets correspond to non-threat and threat sentence completions respectively).  

<table>
<thead>
<tr>
<th>Example Description</th>
<th>Non-Threat Completion</th>
<th>Threat Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>It has been very cold weather lately and you have been having the heater on high to help keep you and your family warm through the night. When the gas bill arrives at the end of the month the amount is</td>
<td>affordable/unaffordable</td>
<td>affordable/unaffordable</td>
</tr>
<tr>
<td>Today you are meeting with your supervisor from your evening language course at college to talk about your last piece of work. He has highlighted some changes you need to make and says that most of your work is</td>
<td>correct/wrong</td>
<td>correct/wrong</td>
</tr>
<tr>
<td>Your boss has asked you to represent him at an important meeting in the city this morning. You arrive at the train platform on time, when an announcement is made over the speakers saying that your train will now be</td>
<td>arriving/delayed</td>
<td>arriving/delayed</td>
</tr>
<tr>
<td>You and your partner have spent the day out looking for a new place to live. When you think about moving into the house that you have seen that you can afford, you can't help but feel</td>
<td>excited/depressed</td>
<td>excited/depressed</td>
</tr>
<tr>
<td>You have many tasks to get done before your weekly meeting with your boss tomorrow. As you look over your list of tasks you realise that you are being very</td>
<td>efficient/slow</td>
<td>efficient/slow</td>
</tr>
</tbody>
</table>

Table 2. Table of information processing biases

<table>
<thead>
<tr>
<th>Information Processing Bias</th>
<th>Tasks used to measure bias</th>
<th>Evidence for bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attentional bias</td>
<td>• Emotional Stroop</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>• Dot-probe</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>• Cued attention</td>
<td>✓</td>
</tr>
<tr>
<td>Interpretive bias</td>
<td>• False recognition memory</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>• Homophone spelling</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>• Priming</td>
<td>✓</td>
</tr>
<tr>
<td>Memory bias - Explicit</td>
<td>• Free recall</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>• Cued recall</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>• Recognition</td>
<td>✗</td>
</tr>
<tr>
<td>Memory bias – Implicit</td>
<td>• Word stem completion</td>
<td>✓/✗</td>
</tr>
</tbody>
</table>
Figure 3. The potential role of Working Memory in worry persistence

- Worry
- Working memory resources consumed
- Trains of worrisome thoughts that are difficult to control
- Reduced working memory available to intentionally control direction of thoughts
- Less able to redirect thoughts away from worry and onto more benign topics
Table 3. Main take home messages

- The key defining feature of generalised anxiety disorder (GAD) is uncontrollable worry.
- Information processing models of GAD propose that the way in which anxious individuals’ process threatening information plays a causal role in worry persistence.
- There is substantial evidence that individuals with GAD and high levels of worry and anxiety demonstrate an attentional bias favouring the encoding of threatening information; as well as an interpretive bias favouring threatening meanings of emotionally ambiguous events and information.
- There is little evidence that anxious individuals show memory bias for threatening information.
- High levels of anxiety and worry have been associated with reduced working memory capacity, which may make it difficult for these individuals to redirect thoughts away from worry and onto more benign topics, thereby causing worry to persist.
- Recent evidence has indicated that it may be possible to train a more benign attentional and interpretive bias in high anxious individuals, and that this may subsequently cause levels of anxiety and worry to decrease.