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Information-Processing Approaches to Understanding Anxiety Disorders

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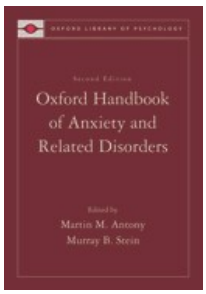

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CHAPTER

12 Information-Processing Approaches to Understanding Anxiety Disorders

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Abstract

Experimental psychopathologists have used cognitive psychology paradigms to elucidate information-processing biases in the anxiety disorders. A vast literature now suggests that patients with anxiety disorders are characterized by an attentional bias for threatening information and a bias toward threatening interpretations of ambiguous information. A memory bias favoring recall of threatening information occurs in panic disorder, but rarely in other anxiety disorders. New treatments involving the experimental modification of cognitive biases are promising.

Keywords: attention, attentional bias, bias, cognitive bias modification, covariation bias, interpretive bias, memory

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Traditional approaches to understanding aberrant cognition in people with anxiety disorders rely on the introspection of patients as disclosed during clinical interviews or on questionnaires (Beck, Emery, & Greenberg, 1985). This approach has proven valuable for identifying maladaptive beliefs and appraisals. For example, the tendency to regard fear-related bodily sensations as harbingers of danger, as measured by the Anxiety Sensitivity Index (ASI) (Reiss, Peterson, Gursky, & McNally, 1986), predicts the eruption of unexpected, "spontaneous" panic attacks (Schmidt, Lerew, & Jackson, 1999) and the subsequent emergence of panic disorder and related syndromes (Schmidt, Zvolensky, & Maner, 2006). Likewise, correcting catastrophic misappraisals of bodily sensations is an efficacious means of treating panic disorder (Clark et al., 1999).

Despite their importance (McNally, 2001), introspective methods are seldom capable of disclosing the mechanisms that give rise to the phenomenology of anxiety disorders (MacLeod, 1993). Accordingly, during the past two decades experimental psychopathologists have used cognitive psychology paradigms to

elucidate biases in attention, memory, and interpretation constitutive of anxiety disorders at the information-processing level of analysis (Harvey, Watkins, Mansell, & Shafran, 2004; Williams, Watts, MacLeod, & Mathews, 1988, 1997).

In this field, the term *bias* refers to a systematic difference in the processing of emotionally relevant information between people with anxiety disorders (or those at risk for them) versus healthy control subjects. It does not necessarily imply inaccuracy or distortion of reality (Mathews & MacLeod, 2005). These content-dependent cognitive *biases* differ from cognitive *deficits*, such as general distractibility, that are apparent irrespective of the emotional significance of the information processed. Our purpose is to review highlights of information-processing research in the field of anxiety and the anxiety disorders. The field is now vast, and hence our coverage is perforce synoptic.

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Attention

Because the human information-processing system has limited capacity, people can only attend to a subset of stimuli at any point in time. Accordingly, any tendency to attend preferentially to threatening stimuli should result in heightened propensity to experience anxiety. People characterized by high trait anxiety, especially those suffering with anxiety disorders, should therefore exhibit an attentional bias favoring the processing of threat-related stimuli.

To test this hypothesis, researchers have developed the emotional Stroop paradigm (Mathews & MacLeod, 1985). In this paradigm, subjects view words of varying emotional significance and are asked to name the colors of the words while ignoring their meaning. Delays in color-naming ("emotional Stroop interference") occur when the meaning of a word captures the subject's attention despite his or her e ort to focus on its color. A bias for threat occurs when subjects take longer to name the colors of threat words than to name the colors of either positive or neutral words.

Patients with anxiety disorders, relative to healthy control subjects, have exhibited greater Stroop interference for threat words than for nonthreat words (for a review, see Williams, Mathews, & MacLeod, 1996). This effect has occurred in specific (spider) phobia (Watts, McKenna, Sharrock, & Trezise, 1986), social phobia (Hope, Rapee, Heimberg, & Dombeck, 1990), posttraumatic stress disorder (PTSD) (McNally, Kaspi, Riemann, & Zeitlin, 1990), panic disorder (Ehlers, Margraf, Davies, & Roth, 1988), generalized anxiety disorder (GAD) (Mathews & MacLeod, 1985), and obsessive-compulsive disorder (OCD) (Foa, Ilai, McCarthy, Shoyer, & Murdock, 1993). There have also been failures to replicate the effect (e.g., PTSD: Freeman & Beck, 2000; panic disorder and OCD: Kampman, Keijsers, Verbraak, Näring, & Hoogduin, 2002).

Most studies, however, suggest that emotionality per se is insufficient to provoke Stroop interference. In one study, panic disorder patients took longer to color-name threat words (e.g., *collapse*) than to color-name positive words (e.g., *cheerful*) even though they rated the latter as more emotional than the former (McNally, Riemann, Louro, Lukach, & Kim, 1992). In another study, positive words signifying the opposite of threat (e.g., *relaxed*) provoked interference in a mixed group of anxious patients (Mathews & Klug, 1993), whereas in other studies of panic disorder (McNally et al., 1994) and OCD (Lavy, van Oppen, & van den Hout, 1994) this did not occur. Taken together, these findings suggest that positive material seldom produces as much Stroop interference as threatening material except, perhaps, when it is conceptually linked to the patient's main concerns.

Studying college students, Riemann and McNally 1995 selected Stroop stimuli idiographically, based on whether the word was relevant to either a subject's positive current concerns (e.g., a new romantic relationship) or a subject's negative current concerns (e.g., financial worries). Subjects exhibited greater interference for words strongly related to either positive or negative current concerns relative to words only

weakly related to these concerns or to control words unrelated to current concerns. This finding raises the possibility that Stroop interference effects arise in anxiety disorder patients because words deeply relevant to their current concerns are seldom relevant for healthy control subjects or to patients with anxiety disorders whose concerns lie elsewhere.

Researchers have investigated whether the emotional Stroop effect is automatic. Tradition holds that an automatic process does not consume cognitive capacity, can operate outside of awareness, and occurs involuntarily (e.g., Shiffrin & Schneider, 1977). These diagnostic criteria for automaticity, however, do not always covary when individuals process threat-relevant material (McNally, 1995). Clearly, the emotional Stroop effect does not constitute automatic processing in the sense of being capacity-free. Indeed, processing the meaning of a threat cue comes at the expense of naming its color, thanks to resources being captured by the meaning of the word. Researchers have asked whether emotional Stroop interference can occur outside of awareness—another sense of the term automatic. Typically researchers present Stroop words very briefly, and then follow each word with a mask (e.g., $#%#*+) comprising characters having the same color as the Stroop word subliminally preceding it. Patients with panic disorder (Lundh, Wikström, Westerlund, & Öst, 1999), GAD (Bradley, Mogg, Millar, & White, 1995; Mogg, Bradley, Williams, & Mathews, 1993), PTSD (Harvey, Bryant, & Rapee, 1996), and spider phobia (van den Hout, Tenney, Huygens, & de Jong, 1997) have exhibited subliminal Stroop interference for threat words. Depressed patients do not exhibit the effect (McNally, Amir, & Lipke, 1996; Mogg & Bradley, 2004).

Despite its seeming obligatory character, the emotional Stroop effect can be overridden when anxious
p. 138 subjects anticipate an imminent, more stressful ↳ experience, such as a possible encounter with the feared animal in snake-fearful individuals (Mathews & Sebastian, 1993), viewing a Vietnam combat video in PTSD patients (Constans, McCloskey, Vasterling, Brailey, & Mathews, 2004), or giving a speech in patients with social phobia (Amir et al., 1996). The signature of this strategic override appears to be a speeding up of color-naming across the board, not only for threat words (Williams et al., 1996).

Although delayed color-naming of threat cues may occur because they capture attention, it may also result from threat cues triggering momentary emotional distress that disrupts task performance, or by capacity consumption arising from patients' struggling to attend to color and avoid being distracted by threat (de Ruiter & Brosschot, 1994; Mathews, 1990). Moreover, the effect does not measure attentional shift toward threat cues; indeed, both semantic and color cues occupy the same physical space (Fox, 1993).

Ambiguities about the mechanism of the emotional Stroop prompted MacLeod, Mathews, and Tata (1986) to devise the dot-probe paradigm as a better measure of attentional bias for threat. In this task, subjects perform a neutral response (a button press) to a neutral stimulus (a dot) that replaces either member of a pair of words appearing simultaneously for 500 ms on a computer screen. On some trials, one member of the word pair is threat-relevant (e.g., *cancer*). On occasional trials, a dot appears, replacing either the threat word or the nonthreat word. MacLeod et al. found that subjects with GAD, relative to either depressed or healthy subjects, were faster to respond to probes that replaced threat words and slower to respond to probes that replaced neutral words. This pattern suggests that the attention of GAD patients was drawn to threat words—a tendency that either speeded or slowed probe detection, depending on whether the probe appeared in the location of a threat or neutral cue, respectively.

To increase the sensitivity of the attentional bias task, researchers have modified it in several ways. In one variant, a threat word appears on each trial, and the subject indicates whether the subsequent dot probe replaced either the upper or lower word (Mogg, Bradley, & Williams, 1995). The reaction time (RT) to ascertain probe position is the measure of attentional deployment. In another version, the probe consists of a pair of dots aligned either vertically (:) or horizontally (..), and the subject classifies the probe as either vertical or horizontal as quickly as possible (Mogg & Bradley, 1999).

Another innovation has been the use of facial expressions of emotion as the stimuli preceding the probe. For example, Mogg and Bradley 1999 simultaneously showed subjects two photographs of the same person, one appearing on the left side of the screen and the other appearing on the right. One face displayed anger, and the other joy. An attentional bias for threat occurred when subjects were faster to respond to the probe that replaced the threat face.

In another experiment, compared to healthy control subjects, those with GAD were faster to detect probes that replaced angry facial expressions than those that replaced neutral facial expressions (Bradley, Mogg, White, Groom, & de Bono, 1999). Each emotional face, either angry or happy, was paired with a neutral face of the same person. Interestingly, over the course of the experiment, the GAD patients exhibited a similar attentional bias for happy faces versus neutral ones.

Using a variant of the dot-probe paradigm, Mansell, Clark, Ehlers, and Chen 1999 found that socially anxious subjects exhibited attentional avoidance of faces displaying either positive (joy) or negative (fear, anger, disgust) emotions, but only when subjects were anticipating having to give a speech. In the absence of speech threat, there was no difference in attentional deployment between high and low social anxiety subjects. The authors interpreted these findings as consistent with the hypothesis that social anxiety is associated with reduced processing of external cues. On the other hand, Gilboa-Schechtman, Foa, and Amir (1999) found that patients with generalized social phobia were faster to detect angry than happy faces in a pictorial display relative to nonanxious control subjects. One possibility is that social anxiety is associated with rapid detection of social threat followed quickly by attentional avoidance.

In an influential theoretical formulation, Williams et al. 1988, pp. 166–184) proposed that anxiety is associated with biased attention to threat, including at the preconscious stage of stimulus processing. In response to stimulus input, an affective decision mechanism classifies the input as posing either high threat or no threat. The resource allocation mechanism of those with high versus low trait anxiety theoretically responds differently if high threat is registered. If the affective decision mechanism indicates the presence of high threat, then those with high trait anxiety allocate attention to the threat, whereas those with low trait anxiety shift their attention elsewhere.

p. 139 But if rapid detection of threat cues is deemed an adaptive feature of the human information-processing system, what, then, distinguishes those with and without an anxiety disorder? Moreover, surely it cannot be adaptive to shift attention away from mortal danger.

Several theorists simultaneously proposed an answer to this question (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998). The key idea here is that individuals varying in trait anxiety differ in terms of when they switch from attentional avoidance to attentional vigilance. Presumably, the threshold for switching from avoidance to vigilance is lower among high trait anxious individuals, including those with anxiety disorders, than among low trait anxious individuals. As Mogg and Bradley 2004 suggested, "biases in the evaluation of threat cues, rather than attentional biases, underlie vulnerability to anxiety" (p. 71). In other words, attentional bias for threat per se is not the fundamental abnormality in anxiety disorders. What distinguishes those with anxiety disorders, or those prone to develop them, is that relatively nonthreatening stimuli are classified as highly threatening, thereby leading to attentional capture by these stimuli. Attentional bias is parasitic on a more fundamental interpretive bias.

Consistent with this view, Wilson and MacLeod 2003 found that both low and high trait anxious subjects exhibit attentional avoidance for faces displaying minimal anger, whereas both groups exhibit attentional vigilance for faces displaying intense anger. Where the groups differ is in their processing of faces displaying moderate anger: high trait anxious subjects, relative to low trait anxious subjects, exhibit attentional vigilance for these faces. Hence, high trait anxious subjects attend to moderate threat as if it signified high threat.

Another issue concerns whether attentional bias reflects rapid capture by threatening stimuli, difficulty disengaging from threat stimuli, or both. Fox and her colleagues found that individuals with elevated trait anxiety experience difficulty disengaging from words associated with threat (Fox, Russo, Bowles, & Dutton, 2001).

Research on attentional bias continues to become increasingly sophisticated. In addition to using reaction-time measures of attentional deployment, researchers have incorporated eye-tracking procedures to study attentional shifts directly. Tracking subjects' eye movements during a dot-probe task, Mogg, Millar, and Bradley (2000) found that GAD subjects without comorbid depression were more likely to direct their gaze at angry than at neutral faces, and they were more likely to shift their gaze more quickly to threat faces than away from them. Neither healthy subjects, nor those with major depression, exhibited these attentional biases for threat.

In other research, psychologists determined that spider phobic subjects, relative to subjects without spider phobia, exhibited attentional capture by spider pictures only when such stimuli were part of a background context they had been told to ignore (Miltner, Krieschel, Hecht, Trippe, & Weiss, 2004). This research team used both reaction time and eye tracking as the basis for its inferences about attentional deployment. As Miltner et al. observed, attentional bias for threat occurs in anxious subjects primarily when they simultaneously confront stimuli of competing valence, a conclusion confirming previous work (MacLeod & Mathews, 1991; Mogg, Mathews, Eysenck, & May, 1991).

Unraveling the complexities of attentional vigilance, avoidance, or both in anxiety is best accomplished by tracking the course of these attentional effects over time (Mogg & Bradley, 2004). There are two ways to do this. In one approach, stimulus duration varies (e.g., 200 ms, 500 ms, 1500 ms). Shorter durations best capture automatic, obligatory attentional capture, whereas longer durations permit strategic avoidance. In the other approach, eye-tracking equipment tracks attentional shifts in real time. Studies of subclinical blood phobics (Mogg, Bradley, Miles, & Dixon, 2004) and subclinical spider phobics (Hermans, Vansteenwegen, & Eelen, 1999; Pflugshaupt et al., 2005; Rinck & Becker, 2006) have documented attentional vigilance for threat cues followed by attentional avoidance. As Pflugshaupt et al. 2005 noted, "As a consequence of initial hypervigilance, phobics are more likely to detect potentially threatening events and thus perceive the world as a dangerous place, while subsequent cognitive avoidance prevents objective evaluation and habituation to such events" (p. 115).

Memory

Most research on memory bias in the anxiety disorders has concerned explicit expressions of memory. Memory is revealed explicitly when task performance requires conscious recollection of previous experiences on free recall, cued recall, or recognition tests. Free recall is usually more sensitive to emotional variables, such as diagnostic status and word valence, than is either cued recall or recognition. A common approach is to have anxious ↳ and control subjects encode words of varying emotional valence by having them either rate the self-descriptiveness of each word (McNally, Foa, & Donnell, 1989) or having them generate an image involving themselves and each word (Becker, Roth, Andrich, & Margraf, 1999). Subjects are later asked to remember the items they encountered previously. A memory bias for threat occurs when anxious patients recall more threat words than either neutral or positive words, relative to control subjects. Another variant is to expose subjects to photographs of faces, and have subjects rate them as exhibiting either a critical (threatening) or accepting (nonthreatening) expression prior to testing memory for the faces (Lundh & Öst, 1996).

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Researchers have also studied implicit memory bias for threat (Amir & Selvig, 2005). Memory is revealed implicitly when previous experiences facilitate ("prime") performance on a task that does not require

deliberate, conscious recollection of these previous experiences (Schacter, 1987). Word-stem completion, perceptual identification, lexical decision, and white noise judgment paradigms are common implicit memory tasks. For the first three tasks, investigators expose subjects to a list of words (e.g., *coffin*). They later have them perform another putatively unrelated task, such as asking them to complete a word stem with the first word that comes to mind (e.g., *cof*), identify words that are briefly flashed on a computer screen, or judge whether briefly flashed letter strings form legitimate words (e.g., *coffin*) or not (e.g., *ceffen*). None of these tasks require conscious recollection of having encountered material previously. But evidence of implicit memory for preexposed material occurs when subjects disproportionately complete word stems with these words (e.g., *coffin*) than with new ones (e.g., *coffee*), identify briefly flashed preexposed words more often than new ones, and make correct lexical decisions more often for preexposed words than for new ones. In a variant of the white noise paradigm (Jacoby, Allan, Collins, & Larwill, 1988), subjects listen and repeat aloud disorder-relevant threat sentences (e.g., "The anxious woman panicked in the supermarket") and neutral sentences (e.g., "The shiny apple sat on the table"). They subsequently hear these old sentences again, intermixed with new threat and neutral sentences. Each sentence is now embedded in white noise of varying volumes, and subjects are asked to rate the volume of the white noise. Evidence of priming occurs when the noise accompanying old sentences seems less loud than that accompanying new sentences. For all of these paradigms, an implicit memory bias occurs when priming is greater for threatening than for nonthreatening material in the anxiety disorder group than in the control group.

Evidence of memory bias for threat is mixed, and it varies as a function of diagnosis and task (Coles & Heimberg, 2002). With few exceptions (e.g., Rapee, 1994), studies have shown that subjects with panic disorder exhibit a free recall bias for negative or threat-relevant words (e.g., Becker, Rinck, & Margraf, 1994; Becker et al., 1999; Cloitre & Liebowitz, 1991; Lim & Kim, 2005; McNally et al., 1989). The bias is sometimes evident on cued recall tests (Cloitre, Shear, Cancienne, & Zeitlin, 1994; Lundh, Czyzykow, & Öst, 1997), but not always (Otto, McNally, Pollack, Chen, & Rosenbaum, 1994), and with few exceptions (Lundh & Öst, 1996), not on recognition tests (Beck, Stanley, Averill, Baldwin, & Deagle, 1992; Ehlers et al., 1988). Vietnam veterans with PTSD likewise are characterized by a free recall bias for negative emotional words (Vrana, Roodman, & Beckham, 1995).

There is very little evidence for explicit memory bias favoring recall of threat-related words in GAD (Bradley, Mogg, & Williams, 1995; Mathews, Mogg, May, & Eysenck, 1989; Mogg, Mathews, & Weinman, 1987; Otto et al., 1994), spider phobia (Watts & Coyle, 1993), or social phobia (Cloitre, Cancienne, Heimberg, Holt, & Liebowitz, 1995; Rapee, McCallum, Melville, Ravenscroft, & Rodney, 1994; Rinck & Becker, 2005; but see Lundh & Öst, 1996).

Although researchers have seldom demonstrated a memory bias favoring threat words among anxiety-disordered patients, work by Friedman, Thayer, and Borkovec (2000) has illuminated why this might be the case. They reported a pronounced free recall bias favoring threat words in GAD patients when these subjects were not constrained by instructions on how to encode the material. As Mathews (2006) has concluded, anxious individuals may very well encode material in terms of its personal emotional threat-value when the task does not require them to encode it in some other manner, and this, in turn, may result in the elusive explicit memory bias for threat appearing.

Conclusions about memory bias, or the lack thereof, must not rest solely on whether anxiety disorder patients are better at recalling threat-related words than words unrelated to threat. For example, Radomsky and Rachman 1999 found that OCD patients with washing rituals, relative to anxious and ↳ nonanxious control subjects, had superior memory for objects that had been "contaminated" by the experimenter than for clean objects, thereby underscoring the importance of ecologically relevant stimuli in cognitive research.

Although some studies have suggested an implicit memory bias for threat in word-stem completion (Mathews et al., 1989) and perceptual identification (MacLeod & McLaughlin, 1995) paradigms, others have not (Mathews, Mogg, Kentish, & Eysenck, 1995; McNally & Amir, 1996; Otto et al., 1994). In retrospect, these implicit memory tasks may not have been the best choice to study automatic processing of emotionally relevant information. Priming effects on both tasks are strongly influenced by the perceptual characteristics of the input, not by meaning, emotional or otherwise (e.g., Schacter, 1992). For example, priming effects are attenuated if subjects are preexposed to words appearing in lowercase letters, but then encounter test stimuli appearing in uppercase letters. In other words, the perceptual rather than the conceptual or semantic aspects of the stimuli drive priming effects on these tasks, rendering them of uncertain relevance to the study of emotional meaning and memory.

To study conceptual implicit memory biases for threat in panic disorder, Amir and colleagues adapted the "white noise" paradigm (Amir, McNally, Riemann, & Clements, 1996). Panic patients tended to exhibit greater priming for threat sentences than for neutral ones, whereas control subjects exhibited the opposite pattern. Similar findings occurred in studies of PTSD patients (Amir, McNally, & Wiegartz, 1996) and social phobia patients (Amir, Foa, & Coles, 2000), but not in one concerning patients with OCD (Foa, Amir, Gershuny, Molnar, & Kozak, 1997). Although this task is clearly conceptually more complex than most implicit memory tasks, it is unclear whether it taps conceptual implicit memory. Confidence that it is a conceptual implicit memory task would be bolstered if the effect occurs when, say, a male voice read the sentences at encoding and a female voice read them at test.

Directed Forgetting and Memory Inhibition

Most research on memory bias in the anxiety disorders considers the possibility that information about threat is characterized by heightened accessibility as revealed on either explicit or implicit memory tasks. Researchers have also tested the ability of anxiety-disordered patients to disengage attention from threat cues in an e ort to forget them (McNally, 2005). In one study, researchers administered an item-cuing directed forgetting procedure to three groups of women (McNally, Metzger, Lasko, Clancy, & Pitman, 1998). One group had PTSD related to childhood sexual abuse (CSA). Another group had been exposed to CSA, but had no PTSD, and a third group had never been sexually abused. Each subject viewed a series of words from one of three categories: trauma-relevant, positive, and neutral. Each word appeared for two seconds and was replaced by either an instruction to forget the word or an instruction to remember. Subjects were later asked to recall all words, irrespective of the original instructions. Both control groups exhibited a directed forgetting effect; they recalled words followed by remember instructions more often than those followed by forget instructions, irrespective of the valence of the words. The PTSD group, however, did not exhibit a directed forgetting effect because they experienced difficulty recalling neutral and positive words they were supposed to remember, and experienced difficulty forgetting trauma words they were supposed to forget.

Several other anxiety disorder groups have likewise either exhibited a breakdown in the ability to forget negative material (OCD: Tolin, Hamlin, & Foa, 2002; Wilhelm, McNally, Baer, & Florin, 1996) or no heightened ability to forget threat material (panic disorder: McNally, Otto, Yap, Pollack, & Hornig, 1999; Power, Dalgleish, Claudio, Tata, & Kentish, 2000). Patients with acute stress disorder, however, are characterized by a superior ability to forget trauma-related words (Moulds & Bryant, 2002, 2005).

Memory Functioning in OCD

Patients with OCD, especially those with checking rituals, seem to suffer impairment in their memory for actions. After having just locked the door, turned o the gas, and so forth, they feel compelled to check or repeat these actions again and again to assure themselves that they did, in fact, perform them rather than merely imagined having performed them. Although this phenomenon seems to imply a deficit in reality monitoring—the capacity to distinguish representations resulting from perception ("reality") from those arising from imagination ("fantasy"), researchers have failed to confirm such deficits (Brown, Kosslyn, Breiter, Baer, & Jenike, 1994; Constans, Foa, Franklin, & Mathews, 1995; McNally & Kohlbeck, 1993); instead they have a deficit in their confidence in their memory (McNally & Kohlbeck, 1993), especially under ↳
p. 142 conditions of heightened responsibility (Radomsky, Rachman, & Hammond, 2001).

In an important series of experiments, van den Hout and Kindt (2003) may have identified the basis for memory distrust in OCD. In their analogue research, they had college students either check the knobs on a virtual gas stove ("relevant checking") or check whether virtual light bulbs were turned o ("irrelevant checking"). They found that repeated checking did not diminish the accuracy of memory for the knobs last checked, but it did diminish the subjects' memory vividness, memory detail, and, most important, confidence in the accuracy of their memory. As the authors emphasized, the problem is not why memory distrust persists despite repeated checking. Indeed, repetitive checking itself impairs memory confidence.

Also testing college students, others have likewise demonstrated that repeated checking undermines confidence in one's memory for actions (Coles, Radomsky, & Horng, 2006; Radomsky, Gilchrist, & Dussault, 2006). Radomsky et al. 2006 demonstrated the effect with a genuine, rather than computerized virtual, stove. Coles et al. 2006 found that memory confidence begins to decline after 2 to 10 checks.

Interpretation

People often encounter situations in everyday life whose meaning is far from obvious. Pain in one's chest may signify a heart attack or merely tense muscles. A ringing phone in the middle of the night may bring news of the death of a loved one or it may merely be a wrong number. Any tendency for interpreting ambiguous stimuli as threatening should be associated with increased anxiety. As noted above, interpretive biases have assumed an increasingly prominent role in information-processing theories of anxiety and the anxiety disorders (e.g., Mogg & Bradley, 2004; Richards, 2004).

Pioneering the study of interpretive bias, Butler and Mathews 1983 developed a booklet consisting of ambiguous scenarios and had patients with generalized anxiety, depression, or no disorder write down the first interpretation that came to mind (e.g., "You wake with a start in the middle of the night, thinking you heard a noise, but all is quiet. What do you think woke you up?"). After responding to each scenario, subjects turned the page and ranked three experimenter-provided interpretations in terms of the likelihood of each coming to mind in a similar situation. Only one interpretation was threatening. Butler and Mathews found that both depressed and anxious patients exhibited a threat bias relative to the control group.

Others have adapted this ambiguous scenario approach, altering the content of the scenarios to capture the concerns of patients with other syndromes. Patients with agoraphobia and panic interpret scenarios involving internal and external ambiguous stimuli as threatening (McNally & Foa, 1987), whereas those with panic disorder exhibit an interpretive bias confined to ambiguous bodily sensations having an abrupt onset rather than ambiguous social or other bodily stimuli (Clark et al., 1997; Westling & Öst, 1995).

These studies suggest that GAD and panic disorder are associated with a bias for interpreting ambiguity as threatening. Because these scenarios might be subject to demand effects, Mathews, Richards, and Eysenck

(1989) devised another method for assessing interpretive bias. They presented GAD patients, recovered GAD patients, and healthy control subjects with an audiotaped series of homophones interpretable in either a threatening (e.g., *die*) or nonthreatening (e.g., *dye*) fashion. When asked to write down the words they heard, subjects with GAD produced more threatening spellings than did healthy control subjects, whereas recovered GAD patients did so to an intermediate degree.

This team devised an even more ecologically relevant method for gauging interpretive bias (Eysenck, Mogg, May, Richards, & Mathews, 1991). They had GAD subjects, recovered GAD subjects, and healthy control subjects listen to audiotaped sentences such as "The doctor examined little Emma's growth." They later asked subjects to identify which sentences had the same meaning of those they had heard previously, and the options included disambiguated versions that were either threatening (e.g., "The doctor looked at little Emma's cancer") or neutral (e.g., "The doctor measured little Emma's growth"). The GAD subjects endorsed threatening and neutral versions to an equal extent, whereas the recovered GAD subjects and the healthy control subjects exhibited a "positivity bias" of sorts by endorsing nonthreatening versions more than threatening ones.

But these findings are consistent with an anxiety-linked response bias for endorsing the threat-related option as well as an interpretive bias for threat. That is, anxious subjects might entertain neutral as well as threatening options, but then choose the threat-related one, at least before having been treated for their
p. 143 anxiety disorder. To rule out response bias, MacLeod and Cohen 1993 devised ↳ a text comprehension program that distinguishes interpretive bias from response bias. They had college students with either high or low trait anxiety read pairs of sequentially presented sentences on a computer screen. The first sentence of each pair had either a threatening, a nonthreatening, or an ambiguous meaning, whereas the second sentence provided a plausible continuation of the first, and had either a threatening or a nonthreatening meaning. Subjects pushed a button to advance from the first sentence to the second one, and pushed it again to advance from the second sentence to the first one of the next pair. This arrangement enabled MacLeod and Cohen to measure the subjects' reading time. The reading comprehension latency for second sentences that follow ambiguous ones revealed patterns of interpretive bias. That is, comprehension latency for the second sentence is inversely correlated with its plausibility as a continuation of the preceding ambiguous one. Hence, if subjects assume a threatening interpretation of an ambiguous first sentence, then they should be faster to read the second sentence if it constitutes a threatening continuation of the first sentence. The advantage of this paradigm is that subjects merely read sentences and push but-tons, thereby minimizing the likelihood of a response bias interpretation of the results. Consistent with their hypothesis, MacLeod and Cohen found that subjects with high trait anxiety were more likely to impose the threatening interpretation on the ambiguous sentences, whereas the low trait anxiety subjects did the opposite.

The study of interpretive bias for threat has become increasingly sophisticated (Richards, 2004). In one paradigm (Amir, Foa, & Coles, 1998), subjects read sentences ending in either a homograph or a nonhomograph that has either a socially threatening or nonthreatening possible meaning, and then decide whether a word appearing either 100 ms or 850 ms later is related to the sentence. For example, subjects might view the sentence "She wrote down the mean" and then decide whether the word "unfriendly" is related to the sentence. Longer decision latencies for words following homographic versus nonhomographic sentences imply that the inappropriate meaning was activated. Amir et al. found that decision latencies in the social phobia group implied activation of the inappropriate meaning for social threat homographic sentences (e.g., "mean" as "cruel" versus "mean" as "average") at 100 ms, but the opposite at 850 ms. This pattern, Amir et al. concluded, implies an automatic activation of threat meaning followed by strategic inhibition of threat in response to ambiguity—a pattern consistent with a vigilance-avoidance style of threat-related information processing (Mogg, Bradley, Bono, & Painter, 1997). Interestingly, precisely the opposite pattern of results emerged in a study of civilian trauma survivors either with or without PTSD (Amir, Coles, & Foa, 2002). Patients with PTSD, relative to healthy trauma survivors, had difficulty

inhibiting threat meanings at the strategic stage of processing, but exhibited enhanced inhibition of threat meanings at the automatic stage of processing.

Most studies on interpretive bias rely on verbal material—scenarios, sentences, and homographs. Amir, Beard, and Bower (2005) developed an ecologically more valid approach to testing for interpretive bias in socially anxious individuals. Amir et al. developed videotaped scenarios, each involving an actor who approached the camera and made either a negative, a positive, or an ambiguous comment (e.g., "That is an interesting shirt you have on"). Subjects were asked to imagine themselves as the recipient of the comment, and to rate the emotional valence of each scenario. Socially anxious students, relative to either high trait anxious students, dysphoric students, or nonanxious ones, rate the ambiguous scenarios are more emotionally negative, thereby confirming their interpretive bias.

Do patients with social phobia impose negative interpretations on ambiguous social stimuli online? Or do they do so retrospectively? To address this issue, Hirsch and Mathews 2000 had subjects read brief social scenarios that included ambiguous passages, and then make speeded lexical decisions about words that implied either a benign or negative interpretation of the passage. Response latencies indicated that nonanxious control subjects made online benign interpretations of ambiguous passages in the text, whereas social phobics did not seem to make any online emotional inferences. That is, social phobics seem to lack a positivity bias that is present in nonanxious control subjects. Others have likewise found that socially anxious individuals seem best characterized by an attenuated positivity bias in the face of ambiguous social cues rather than an outright negative interpretive bias (Constans, Penn, Ihen, & Hope, 1999). In fact, patients with social anxiety disorder appear to experience deficits in acquiring positive interpretations of ambiguous social stimuli (Amir, Beard, & Przeworski, 2005).

Covariation Bias

p. 144 Covariation bias is the tendency to overestimate the frequency with which two stimuli co-occur. ↳ Researchers have hypothesized that the tendency to overestimate the frequency with which feared stimuli occur with negative consequences may play a role in the development and maintenance of anxiety disorders. This may be one reason why individuals continue to fear certain objects, animals, or situations despite the absence of a correlation between the feared object and a negative outcome in their environment.

Devising an illusory correlation procedure, Tomarken, Mineka, and Cook 1989 pioneered the study of covariation bias. High and low spider-or snake-fearful individuals viewed photographs of their feared animal (snake or spider), mushrooms, and flowers one at a time. Each photograph was followed randomly by one of three outcomes: a mild electric shock, a tone, or nothing. Subjects were instructed to pay attention to the relationship between the photographs and the outcomes. After the experiment, subjects were asked to estimate the frequency with which each type of photograph was paired with each outcome. Although there was no correlation between photograph type and outcome, high-fear subjects significantly overestimated the frequency with which their feared animal and the shock were paired relative to all other stimulus-outcome pairs and relative to the true frequency. Low-fear subjects displayed a similar, but attenuated pattern of estimates. Tomarken et al. interpreted this covariation bias as evidence that fearful individuals processed information during the experiment in a manner that confirmed their fear.

Other researchers, however, suggested that perhaps the tendency to associate feared stimuli with a negative outcome is not the result of biased online processing, but is present in fearful individuals even before the experiment begins (de Jong & Merckelbach, 1990). To test this hypothesis, Davey 1992 asked nonfearful individuals to participate in a threat conditioning paradigm in which they viewed a series of photographs and were told that some of the photographs may be followed by an electric shock. Although no shock was ever delivered, Davey found that individuals who viewed fear-relevant stimuli (snakes and spiders)

expected shock to occur significantly more often than those individuals who viewed fear-irrelevant stimuli (kittens and pigeons) providing support for an expectancy bias for phylogenetically fear-relevant stimuli. McNally and Heatherton 1993 asked high and low snake-fearful participants to *imagine* that they were to participate in an illusory correlation paradigm nearly identical to that conducted by Tomarken et al. 1989. Subjects were then asked to predict the frequency with which each photograph type would be paired with each outcome. The results closely mirrored those of Tomarken et al. 1989; all subjects demonstrated an expectancy bias for fear-relevant stimuli, although it was attenuated in low-fear subjects. This suggests that an expectancy bias for phylogenetically fear-relevant stimuli may be influenced by, but not dependent upon, prior fear. McNally and Heatherton then tested individuals with high or low fear of damaged electrical outlets, and found that both groups exhibited an expectancy bias for damaged electrical outlets and shock regardless of prior fear level, suggesting that expectancy bias is not specific to phylogenetically fear-relevant stimuli. Given that postexperimental covariation biases had occurred for phylogenetically fear-relevant stimuli, but not for ontogenetically fear-relevant ones (Sutton, Mineka, & Tomarken, 1991), McNally and Heatherton suggested that expectancy biases involving phylogenetic threat cues may be characterized by a disconfirmation insensitivity.

Kennedy, Rapee, and Mazurski 1997 sought to clarify some of the early findings in this area by conducting a study in which individuals high and low in fear of both snakes or spiders *and* damaged electrical outlets made both pre-and postexperimental covariation estimates within the same experiment. Following McNally and Heatherton 1993, they had subjects first predict the frequency with which spiders, electrical outlets, and flowers would be paired with a shock, tone, or nothing in an imaginary illusory correlation paradigm. After making these expectancy estimates, subjects then participated in the illusory correlation paradigm they had just imagined and made postexperimental covariation estimates. The authors found that all individuals demonstrated expectancy biases for both the ontogenetically and phylogenetically fear-relevant stimuli and shock regardless of fear level. However, covariation bias was only exhibited by high-fearful individuals for the phylogenetic stimuli. The authors concluded that perhaps both prior fear and fear-relevance of the stimuli influence the degree to which expectancy biases are modified by the illusory correlation paradigm.

In a similar study, Amin and Lovibond 1997 had undergraduates participate in an illusory correlation paradigm in which fear-relevant stimuli (either phylogenetic or ontogenetic), flowers, and mushrooms were followed by a shock, a tone, or nothing. The authors measured online expectancy biases as well as
p. 145 postexperimental biases. Confirming ↳ Kennedy et al.'s findings, an expectancy bias occurred for both classes of stimuli and was not influenced by prior fear level. Only high-fearful subjects exhibited a covariation bias for the phylogenetically fear-relevant stimuli. Taken together, these studies suggest that expectancy biases exist for both phylogenetically and ontogenetically fear-relevant stimuli and are not influenced by prior fear level. In contrast, covariation biases may be influenced by both the prior fear level of the individual and whether the stimuli are phylogenetically or ontogenetically fear-relevant. However, the results by Amin and Lovibond cast some doubt on the hypothesis that covariation biases are merely expectancy biases that have not been modified by situational information during the illusory correlation paradigm. In their measurements of online expectancies, the authors found that the expectancy bias for the phylogenetically fear-relevant stimuli and the shock had disappeared by the end of the experiment, and so the covariation bias cannot simply be a continuation of the expectancy bias. The authors argue that perhaps covariation biases are influenced by biases in memory such that even though subjects have corrected their online estimates by the end of the experiment, they place more weight on their prior expectancies when making their postexperimental estimates.

Researchers have also examined various attributes of the stimuli and outcomes that may influence expectancy and covariation biases. Work by Davey and Dixon 1996 suggests that estimates of the dangerousness of the stimuli, as well as the degree of similarity between the stimuli and the outcomes with

regard to valence, arousal, and anxiety may influence the degree to which an expectancy bias occurs. Indeed, a study by Davey and Craigie 1997 found that experimentally increasing an individual's estimates of the dangerousness of one of the experimental stimuli led to significantly greater expectancy and postexperimental covariation estimates for that stimulus and the negative outcome. Tomarken, Sutton, and Mineka (1995) present evidence to suggest that the degree of affective response matching between the stimulus and the outcome is more relevant than the degree of semantic belongingness between the stimulus and outcome in determining covariation bias.

The findings in snake and spider fear have usually been replicated in panic disorder (Pauli, Montoya, & Martz, 1996, 2001; Wiedemann, Pauli, & Dengler, 2001). In contrast, a different pattern of results has emerged for blood-injury injection phobia and social anxiety disorder. Pury and Mineka 1997 found that all individuals regardless of fear level significantly overestimated the frequency with which photographs of surgery and mutilated bodies were paired with shock. Similarly, de Jong, Merckelbach, Bögels, and Kindt (1998) found preexperimental and online expectancy bias, as well as postexperimental covariation biases, for angry faces and shock regardless of subjects' level of prior social anxiety. Thus, prior fear may not moderate covariation bias in these two areas. In both of these cases the authors argue that the blood-related stimuli and the angry faces may be inherently negative, whereas spiders, snakes, and panic-relevant scenes are only negative for those individuals who fear those stimuli. Therefore, there may be an affective match between the blood-related stimuli or angry faces and the shock for all individuals regardless of fear.

Are Biases Correlates or Causes of Anxiety Disorders? Cognitive Bias Modification

Clinical recovery is accompanied by the attenuation or elimination of attentional biases for threat in PTSD (Foa, Feske, Murdock, Kozak, & McCarthy, 1991), spider phobia (Lavy, van den Hout, & Arntz, 1993; Watts et al., 1986), OCD (Foa & McNally, 1986), and GAD (Mathews et al., 1995; Mogg, Bradley, Millar, & White, 1995). Mattia, Heimberg, and Hope 1993 found that patients with social phobia treated successfully with either phenelzine or group cognitive behavior therapy (CBT) no longer exhibited delayed color-naming of social threat words, whereas those remaining symptomatic continued to exhibit the emotional Stroop effect. Interpretive biases for threat likewise diminish or remit in patients with panic disorder (Clark et al., 1997; McNally & Foa, 1987; Westling & Öst, 1995) and GAD following treatment (Eysenck et al., 1991; Mathews, Richards, et al., 1989). There is mixed evidence regarding covariation bias. Treatment has abolished postexperimental covariation bias for spiders and shock in spider phobics in some (de Jong & Merckelbach, 1993; de Jong, Merckelbach, Arntz, & Nijman, 1992), but not all (de Jong & Merckelbach, 1991), studies. Additionally, de Jong, van den Hout, and Merckelbach (1995) found that the degree of residual covariation bias after treatment significantly predicted the degree of return of fear 2 years posttreatment. De Jong, Merckelbach, and Arntz (1995) found that, although treated spider phobics no longer exhibited a preexperimental bias for spiders and shock, both treated and untreated phobics demonstrated an online
p. 146 expectancy bias and a postexperimental covariation ↳ bias. The authors suggest that perhaps treatment eliminated the expectancy bias, but the presentation of spider-shock pairings during the experiment may have reinstated the previous bias.

Studies have shown that a subliminal attentional bias for threat predicted emotional distress to a subsequent stressor (MacLeod & Hagan, 1992; van den Hout, Tenney, Huygens, Merckelbach, & Kindt, 1995). Using the homograph interpretive bias paradigm, Amir and Beard 2004 found that students with elevated ASI scores (but no history of panic) exhibited automatic activation of threat meanings relative to those with low ASI scores, a finding consistent with previous research on interpretive bias and anxiety sensitivity in nonpanickers (McNally, Hornig, Ho man, & Han, 1999). Of course, a third variable might be fostering the prodromal cognitive bias and elevating risk for later disorder or intense distress. Accordingly,

the most convincing demonstration that they play a causal role in the emergence of disorder is to manipulate biases and to ascertain their emotional consequences (MacLeod, Campbell, Rutherford, & Wilson, 2004).

MacLeod and colleagues modified the dot-probe task so that the probe either always replaced the threat word for one group of subjects or always replaced the neutral word for another group of subjects (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). The subjects were students scoring in the midrange in terms of trait anxiety. After training was completed, a block of dot-probe trials confirmed that the first group had, indeed, acquired an attentional bias for threat, whereas the second group acquired an attentional avoidance for threat. All subjects then completed a series of difficult anagrams under timed conditions. The negative emotional response to this stressor was attenuated in the group that had undergone attentional avoidance training relative to the group that had undergone attentional bias training. A second experiment replicated the findings of the first, and it also documented that the magnitude of the anxiety response to the stressor was directly related to the extent to which the attentional bias was modified.

Researchers have likewise explored attempts to modify interpretive bias (Yiend & Mackintosh, 2004). The core feature of these procedures is that subjects are exposed to ambiguous material that subjects, in turn, use to perform a subsequent task. For one group of subjects, a threatening interpretation of the ambiguous material fosters successful performance of the later task, whereas for another group of subjects a benign interpretation facilitates task performance. Interpolated test trials confirm that subjects in each group have acquired either the negative or the benign interpretive bias.

For example, Grey and Mathews 2000 presented subjects with homographs (e.g., *batter*) followed by a word fragment whose solution disambiguated the homograph in either a benign (e.g., p_nc_ke [pancake]) or negative (e.g., ass_ _lt [assault]) manner. Subjects pressed a key as soon as they had guessed the complete word, and then they typed in the first missing letter. Subjects received trials involving either benign or negative solutions before being tested on new items. Confirmation of the acquired interpretive bias was evinced by faster responses for solutions that matched the valence of the solutions presented during training.

Researchers have shown how an interpretive bias established with one procedure generalizes to a very different format (Hertel, Mathews, Peterson, & Kintner, 2003). Hertel et al. trained college students to interpret homographs in either a threat-related or threat-unrelated manner prior to having them generate visual images prompted by single words, some of which were homographs potentially related to threat. Subjects trained to disambiguate stimuli in a threat-related fashion exhibited a heightened tendency to generate negative images in response to homographic prompt words.

Mathews and Mackintosh 2000 devised methods involving more complex textual material. During the training phase, subjects read brief accounts of ambiguous social scenarios, each concluding with a word fragment whose solution disambiguated the preceding text. So, one example read:

> Your partner asks you to go to an anniversary dinner that their company is holding. You have not met any of their work colleagues before. Getting ready to go, you think that the new people you will meet will find you [either b_r_ng or fr_e_dly].

Subjects in the negative condition saw the fragment whose solution imposed a negative interpretation on the passage (*boring*), whereas those in the other condition saw the fragment whose solution imposed a benign interpretation on the passage (*friendly*). After completing the fragment, subjects in each condition answered questions designed to reinforce either a negative or benign interpretive bias (e.g., "Will you be disliked by your new acquaintances?"), compelling the subject to answer either "yes" or "no," depending on the condition.

p. 147 Following training, subjects then viewed another set of ambiguous scenarios, each followed by a word fragment completion and a comprehension question, but these remained ambiguous and hence did not constrain interpretation. Accordingly, Mathews and Mackintosh were able to assess whether subjects had acquired either a negative or benign interpretive bias by examining how subjects disambiguated these test scenarios. Additionally, they had subjects perform a recognition task by rating each of four sentences with regard to how closely they captured the gist of the preceding text. So, for example, subjects read about "The wedding reception" scenario (Yiend & Mackintosh, 2004):

> Your friend asks you to give a speech at her wedding reception. You prepare some remarks and, when the time comes, get to your feet. As you speak, you notice that some people in the audience start to l_ _ gh [i.e., *laugh*]

Subjects then answered the (ambiguous) comprehension question:

> Did you stand up to speak? [yes/no]

And then they provided recognition ratings of the following four sentences, two involving a positive interpretation of the scenario, and two involving a negative interpretation. Within each valence, one sentence was a target that constituted a paraphrase of the scenario, whereas the other was a valence-congruent foil. For the previous example, the negative foil, positive foil, negative target, and positive target were as follows:

> As you speak, some people in the audience start to yawn.
>
> As you speak, some people in the audience applaud your comments.
>
> As you speak, some people in the audience find your e orts laughable.
>
> As you speak, people in the audience laugh appreciatively.

The results of this research indicate that subjects acquiring a negative interpretive bias provide higher ratings for both negative sentences than for positive ones, and more so for the negative target than for the negative foil. This suggests that subjects are exhibiting a general negative interpretive bias.

Further research indicates that this induced negative interpretive bias persists for at least 24 hours (Yiend, Mackintosh, & Mathews, 2005), but results are mixed regarding whether it heightens subsequent affect in response to a laboratory stressor. In one study, subjects who received negative interpretive bias training did exhibit heightened negative emotional reactivity in response to stressful videos involving television news footage of disasters and emergencies (Wilson, MacLeod, Mathews, & Rutherford, 2006), whereas in another study it did not result in heightened reactivity to a stressful anagram task (Salemink, van den Hout, & Kindt, 2007).

Summary and Conclusions

Work on cognitive biases associated with anxiety and the anxiety disorders began with the assumption that anxiety would affect all aspects of cognitive processing: attention, interpretation, memory, and so forth, and it would operate similarly across the anxiety disorders. The aforementioned synoptic review documents how data-driven theorizing has evolved during the past two decades. Anxiety has much more robust effects on attention and interpretation than it does on explicit memory, with several notable exceptions, and certain abnormalities have emerged that appear unique to certain disorders. For example, work on OCD shows that impaired confidence in one's memory for action appears to be a consequence rather than a cause of repeated checking.

The most important recent developments concern the establishment of the causal status of attentional and interpretive biases for threat. This work, in turn, has inspired the development of new treatments for anxiety disorders based on the direct manipulation of attentional and interpretive biases.

Finally, researchers have begun to explore the neural substrates of processing of emotional material (Mathews, 2006). If this work bears fruit, we will witness a cognitive neuroscience of information-processing bias to supplement the now-established cognitive psychology of this aspect of psychopathology.

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