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Running Head: COGNITIVE VULNERABILITY TO ANXIETY

Cognitive Vulnerability to Anxiety: A Review and an Integrative Model

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Abstract

Consistent research evidence supports the existence of threat-relevant cognitive bias in anxiety, but there remains controversy about which stages of information processing are most important in the conferral of cognitive vulnerability to anxiety. To account for both theoretical and empirical discrepancies in the literature, an integrative multi-process model is proposed wherein core assumptions of dual-systems theories from social and cognitive psychology are adapted to explain attentional and interpretive biases in the anxiety disorders. According to the model, individual differences in associative and rule-based processing jointly influence orientation, engagement, disengagement, and avoidance of threat-relevant stimuli, as well as negatively-biased interpretation of ambiguous stimuli in anxious populations. By linking anxiety-related symptoms to basic principles of information processing, the model parsimoniously integrates different kinds of cognitive biases in anxiety, providing a useful framework for future research and clinical intervention.

Key Words: Anxiety; Dual Process Models; Attention Bias; Information Processing; Cognitive Vulnerability

A well-replicated finding in various areas of psychology is that individuals tend to process information in a manner that is consistent with their views of the world and themselves (e.g., Beck, 1967). Such biases can also be found in anxious individuals, who often show selective processing that fits their view of the world as dangerous. As such, a large body of research has investigated the extent to which the preferential processing of threat-relevant material is related to symptoms of anxiety (e.g., Mogg & Bradley, 2004). Within this literature, however, is considerable controversy regarding which stages of information processing are most important in the conferral of cognitive vulnerability to anxiety disorders. Whereas some research indicates a significant role of attentional biases (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007) other research emphasizes the importance of interpretive biases (e.g., Amir, Beard, & Bower, 2005). Moreover, models of attention differ in their focus on early (e.g., orientation, engagement) versus later (e.g., disengagement, avoidance) stages of processing (e.g., Koster, Crombez, Verschuere, & De Houwer, 2004; Vassilopoulos, 2005), as well as in the proposed mechanisms underlying threat-relevant attention biases (e.g., Fox, 2004).

To overcome these disparities, some researchers have posited that the distinction between automatic and strategic processes may be critical to understanding the mechanistic underpinnings of information processing in anxiety (e.g., Beck & Clark, 1997; McNally, 1995). Automatic processes are characterized as unconscious, unintentional, uncontrollable, and efficient in their use of cognitive resources (Bargh, 1994). In contrast, strategic processes are conscious, intentional, controllable, and inefficient, in that they require a considerable amount of cognitive resources. However, many experiments relying on this distinction have generalized from individual processing features to automaticity per se (e.g., unintentional, therefore automatic), which seems premature given the lack of covariation between features of automaticity (see Moors & De Houwer, 2006). For instance, the fact that a process is initiated without intention (i.e., unintentional) does not imply that it cannot be stopped once initiated (i.e., uncontrollable). In fact, it appears that many cognitive functions comprise elements of both, which may challenge the utility of dividing the realm of anxiety-related processes into automatic and strategic ones (McNally, 1995). Moreover, the creation of "process-pure" measures of information processing has proven extremely difficult, in that any measure comprises a mix of multiple distinct automatic and strategic processes (Sherman et al., 2008), which further challenges the usefulness of the aforementioned distinction as an integrative conceptual tool.

In this article, we argue that contemporary dual-systems models of information processing (e.g., Gawronski & Bodenhausen, 2006; Lieberman, 2003; Sloman, 1996; Smith & DeCoster, 2000; Strack & Deutsch, 2004) may provide an integrative, yet parsimonious framework for the study of cognitive biases in anxiety. Even though these models differ in several of their details, they share the theoretical contention that human judgment and behavior are determined by the interplay between associative and rule-based processes. Whereas associative processes can be characterized as the rapid activation of associated concepts via spreading activation, rule-based processes involve the rational analysis of factual relations between concepts. Attesting to the usefulness of dual-systems models in the clinical domain, the core assumptions of these models have already been incorporated into cognitive theories of depression (Beevers, 2005; Haeffel et al., 2007), posttraumatic stress disorder (Brewin, Dalgleish, & Joseph, 1996), and addiction (Wiers et al., 2007). Expanding on these advances, the present article proposes a multi-process model of anxiety wherein threat-relevant attentional and interpretive biases, believed to confer vulnerability to anxiety, are reinterpreted using the core assumptions of dual-systems models. Specifically, associative and rule-based processes are purported to provide unique contributions to all stages of processing threat-related stimuli, including orientation, interpretation, engagement, disengagement, and avoidance. Following a review of cognitive biases in anxiety and a basic description of dual-systems models, we present our multi-process model of cognitive vulnerability to anxiety[1]. This model is then used to integrate extant research examining individual components of information processing, with the purpose of better understanding how individual differences in associative and rule-based processing may interact to confer cognitive vulnerability to the anxiety disorders.

Cognitive Biases in Anxiety

Fear and anxiety can be regarded as normal, adaptive reactions to potentially threatening stimuli. Identifying objects or situations that may threaten an organism's survival activates cognitive, affective, physiological, and behavioral processes which serve to ensure the organism's safety (LeDoux, 1996). Pathological anxiety, however, involves the *over*-activation of these resources (Barlow, 2002). Although the anxiety disorders are often differentiated by the specific content of their fears and accompanying symptoms, they share similar underpinnings in terms of both vulnerability and general mechanisms (Mineka, Watson, & Clark, 1998).

Current models of cognitive vulnerability to anxiety posit that individual differences in the processing of threat-relevant material contribute to the etiology and maintenance of the anxiety disorders (e.g., Beck & Clark, 1997; Eysenck, 1992). Theories are differentiated, however, by the relative roles attributed to various stages of information processing. In particular, researchers have focused on the function of either *selective attention* to threatening stimuli (e.g., Mathews & MacLeod, 1985; Mogg, Garner, & Bradley, 2007) or *biased interpretation* of ambiguous information (e.g., Amir et al., 2005; Yoon & Zinbarg, 2007). Additionally, models of selective attention vary in their focus on different stages of processing, namely orientation (e.g., < 30 ms), engagement (e.g., 30-500 ms), disengagement (e.g., 500-1000 ms), and avoidance (e.g., Fox, Russo, Bowles, & Dutton, 2001). Interestingly, although each of these models garnered empirical support, their explanations of cognitive biases in anxiety have not yet been integrated in a general framework and, in fact, seem partially inconsistent with each other.

Attentional Biases

A large body of evidence indicates that people with anxiety pay more attention to threatening stimuli than do non-anxious controls (for a meta-analysis, see Bar-Haim et al., 2007). This research is consistent with conceptual models of anxiety hypothesizing an over-activation of normal reactions to danger, resulting in a hypervigilance for threatening stimuli among anxious individuals (e.g., Barlow, 2002). This attentional bias has been demonstrated in nonclinical samples of individuals with high trait and/or state anxiety (e.g., Mogg et al., 2000), showing content specificity for threat-related stimuli relevant to generalized anxiety disorder (GAD; Mathews & MacLeod, 1985), spider phobia (Watts, McKenna, Sharrock, & Trezise, 1986), obsessive-compulsive disorder (OCD; Tata, Leibowitz, Prunty, Cameron, & Pickering, 1996), posttraumatic stress disorder (PTSD; Foa, Feske, Murdock, Kozak, & McCarthy, 1991), social phobia (SP), and panic disorder (PD; Hope, Rapee, Heimberg, & Dombeck, 1990). It is important to recognize, however, that attention is not a unitary construct (see Posner, 1980). Instead, attention can be divided into four conceptually distinct stages: (1) *orientation* of attention toward a given stimulus; (2) attentional *engagement* with that stimulus; (3) *disengagement* from attending to the stimulus; and (4) *avoidance* of attention to the stimulus.

Orientation and Engagement. Biases at the orientation and engagement phases of attention have often been assessed using emotional Stroop tasks (e-Stroop) and dot-probe paradigms. The e-Stroop, first introduced by Gotlib and McCann (1984), consists of several trials which require individuals to indicate the color in which an emotionally-valenced word is printed. Typically, experiments include different categories of words (e.g., negative, neutral, positive), and the speed with which people are able to identify the color is measured. Increased response latencies in color naming are believed to indicate that attention towards the meaning of a word distracts participants from naming the color of the word (MacLeod, 1991). Indeed, research has demonstrated that individuals with high levels of anxiety are slower to name the colors of negatively-valenced words compared to neutral words (e.g., Kyrios & Iob, 1998). Additionally, anxious groups have exhibited significantly greater interference in naming the color of threat-related words than have non-anxious groups (e.g., Musa, Lépine, Clark, Mansell, & Ehlers, 2003).

The dot-probe paradigm was originally developed by Posner, Snyder, and Davidson (1980) and first adapted for use in psychopathological research by MacLeod, Mathews, and Tata (1986). This task consists of the simultaneous presentation of two differently-valenced stimuli (e.g., words, faces) on separate areas of a screen (e.g., top/bottom, left/right). On the critical trials, a neutral probe (typically a dot or letter) appears in the location of one of the stimuli, and participants are required to indicate as quickly as possible the presence of the probe. Short response latencies indicate that the participant already attended to the area of the screen where the probe appeared, whereas long response latencies suggest that he or she had to shift attention to the previously unattended area in order to detect the probe. This interpretation is supported by research demonstrating that dot-probe detection response latencies are correlated with eye movements from one area of the screen to another (Bradley, Mogg, & Millar, 2000).

For anxiety research, the stimulus pairs typically include a threatening and a neutral stimulus (e.g., Mogg & Bradley, 2002), although some studies have also examined attention to positive material (e.g., Bradley et al., 2000; Fox, 2002). Results from experiments using the dot-probe paradigm are consistent with those documented in the e-Stroop literature, in that anxious groups tend to show greater attentional biases to threat-related stimuli than do non-anxious groups (e.g., Bar-Haim et al., 2007). Egloff and Hock (2003) indicated that the e-Stroop and dot-probe paradigms measure similar constructs, as demonstrated by significant correlations between the two measures for both subliminal and supraliminal presentations. Additionally, a recent meta-analysis suggests that both paradigms are equally effective at uncovering within-subjects and between-groups effects with regards to facilitated engagement with threat-relevant material among anxious groups (Bar-Haim et al., 2007).

These paradigms have also been used to examine potential differences between orientation and engagement by manipulating the presentation duration of the stimuli. For instance, several experiments have used subliminally-presented, masked stimuli (14-30 ms) to investigate attentional biases in the orientation to threat-related stimuli. Such preconscious attentional biases have been demonstrated using either the e-Stroop or dot-probe paradigms in individuals with high trait anxiety (e.g., Mogg & Bradley, 2002), GAD (Bradley, Mogg, Millar, & White, 1995), PTSD (Harvey, Bryant, & Rapee, 1996), PD with agoraphobia (Lundh, Wikstrom, Westerlund, & Ost, 1999), and SP (Mogg & Bradley, 2002). Although the majority of these studies also found attentional biases for supraliminally-presented stimuli, some researchers suggest that experimentally observed attention bias in clinically anxious samples may be largely attributable to preconscious orienting responses to threatening stimuli rather than to later, more conscious engagement processes (e.g., Lundh et al., 1999; Mogg, Bradley, Williams, & Mathews, 1993). This conclusion is in line with research examining the neural circuitry that may underlie anxiety. Specifically, neural structures (in particular the amygdala) may be directly associated with anxiety responses, orienting attention towards biologically threat-relevant stimuli before the meaning or even the actual nature of the stimulus can be consciously detected and evaluated (see Frewen, Dozois, Joanisse, & Neufeld, 2008). Thus, individual differences in this neural circuitry likely contribute to cognitive vulnerability to the anxiety disorders (Davis & Whalen, 2001). Interestingly, in a study examining selective attention to social threat, van Honk and colleagues (2001) found differential neuroendocrine activation patterns in response to preconscious versus conscious attention to angry faces. This finding suggests that threat-related attention biases during orientation and engagement may have distinct links with vulnerability to anxiety.

Addressing unique relations of orientation and engagement to anxiety, a few studies provided evidence for the differential predictive power of attentional biases at subliminal (i.e., orientation) and supraliminal (i.e., engagement) exposures. For example, van den Hout, Tenney, Huygens, and Merckelbach (1995) asked participants with different levels of trait anxiety to complete an e-Stroop with threatening and non-threatening stimuli. The stimuli were presented either subliminally (30 ms, then masked until vocal response) or supraliminally (presented until vocal response). To measure emotional vulnerability, participants were asked to rate how upset they would feel (on a scale from 0-100) in 15 different stressful situations. Although trait anxiety was related to attentional biases for both subliminal and supraliminal presentations, emotional vulnerability was uniquely predicted by attentional biases at the subliminal level (see also MacLeod & Hagan, 1992). Ancillary support for the assumption that orienting bias may have stronger links to emotional vulnerability than engagement bias comes from research on differential neuroendocrine functioning during early compared to later processing of threat (e.g., Straube, Mentzel, & Miltner, 2006). Additionally, Najstrom and Jansson (2007) found that enhanced skin conductance to subliminally-presented threatening pictures (compared to neutral pictures) was a significant predictor of emotional responses to later stressful events (after controlling for trait anxiety). Deviating from these results, a study examining the predictive power of subliminal and supraliminal biases on emotional responding to a biological challenge task (i.e., inhalations of CO_2) found that orienting and engagement biases were equally powerful in predicting emotional responses (Nay, Thorpe, Roberson-Nay, Hecker, & Sigmon, 2004). However, in evaluating this apparent inconsistency, it is important to note that the biological challenge task employed in this study is relatively specific to anxiety sensitivity and panic (e.g., Schmidt & Lerew, 2002), and may therefore have had limited effects on anxiety levels in an unselected undergraduate sample.

Engagement and Disengagement. Following orientation and engagement with a stimulus, disengagement typically takes place (Posner, 1980). This ability to switch attention from one stimulus to another, however, is hypothesized to be particularly difficult for anxious individuals if the engaged stimulus is threat-relevant. Indeed, a number of researchers have argued that threat-relevant attention biases towards supraliminal stimuli (~500 ms) reflect difficulty disengaging from frightening stimuli, rather than enhanced attentional engagement (e.g., Fox et al., 2001). These models posit that orientation to high threat is a normal and adaptive reaction for all humans, regardless of anxiety levels, but that reduced ability to control or stop attending to threatening stimuli may confer a specific vulnerability to pathological anxiety.

As previously mentioned, dot-probe tasks typically involve stimulus pairs, with probes appearing randomly in the location of either a threat-related stimulus (congruent trials) or a neutral stimulus (incongruent trials). By comparing participants' reaction times on these trials to reaction times on trials with two neutral stimuli, engagement and disengagement can be disentangled (Koster et al., 2004). For example, Salemink, van den Hout, and Kindt (2007a) compared high- and low-trait anxious individuals on reaction times to congruent, incongruent, and neutral trials. Results showed that high- and low-anxious participants responded to congruent trials as quickly as they did to neutral trials, indicating that engagement with threat-related stimuli did not differ from engagement with neutral stimuli. An examination of incongruent trials, however, revealed a difficulty disengaging from threatening stimuli in the high-anxious group. These findings suggest that, at least in high trait anxious samples, impaired disengagement may be the driving force behind threat-related attention biases (see also Amir, Elias, Klumpp, & Przeworski, 2003). However, studies using presentation times ranging from 100 ms to 1250 ms obtained inconsistent findings regarding enhanced engagement and impaired disengagement in anxious samples (e.g., Fox et al., 2001; Fox, Russo, & Dutton, 2002; Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006; Vassilopoulos, 2005).

Derryberry and Reed (2002) examined attentional biases exhibited by high- and low-trait anxious participants at presentation durations of 250ms and 500 ms. Using an attentional game paradigm, wherein locations are cued as either threatening (75% chance of losing 10 points if incorrect) or safe (75% chance of gaining 10 points if correct), high-anxious participants were quicker than low-anxious individuals to attend to threat locations at 250ms presentations (attentional bias) and safe locations at 500ms presentation (attentional avoidance). Close examination of the data indicated that the attentional bias was attributable to impaired disengagement rather than to enhanced engagement.

In contrast to these findings, several studies employing visual search paradigms have demonstrated attentional biases at both engagement and disengagement (e.g., Gilboa-Schechtman, Foa, & Amir, 1999; Juth, Lundqvist, Karlsson, & Öhman, 2005). In visual search paradigms, participants are typically asked to search for a target stimulus within a matrix of distracter stimuli. Engagement is measured by comparing detection times on trials where the participant has to find a threatening target among neutral distracters to trials where both targets and distracters are neutral; disengagement is measured with trials where the goal is to detect a neutral target among threatening distracters. In line with studies showing attentional biases at both engagement and disengagement in visual search tasks (e.g., Gilboa-Schechtman et al., 1999; Juth et al., 2005), some researchers argue that biased processing in anxious individuals occurs at all attentional phases, but that each phase may be differentially important (Koster et al., 2006).

Avoidance. In contrast to models that highlight the importance of inhibited disengagement from threat in anxious individuals, some researchers posit that anxiety is characterized by initial orientation and engagement with threat, followed by avoidance of frightening material, most likely as a coping mechanism (e.g., Koster, Crombez, Verschuere, Vanvolsem, & De Houwer, 2007; Vassilopoulos, 2005). For instance, Calvo and Avero (2005) investigated continuous eye movements in response to grey-scale and color photographs varying in valence (neutral, threat, harm, and positive) presented for 3 seconds each to high- and low-trait anxious individuals. Compared to low-anxious participants, high-anxious individuals oriented quicker to all emotional pictures (as measured by first fixation), remained engaged for a longer period with positive and harm-related pictures during the first 500 ms, and then showed avoidance of harm scenes during the last 1500ms. Mogg and Bradley (2004) investigated the time course of attentional bias to spider pictures in individuals with spider phobia and a non-anxious control group. Using a dot-probe task, Mogg and Bradley presented picture pairs of spiders and cats for stimulus durations of 200 ms, 500 ms, and 2000 ms, and examined response latencies to subsequent targets appearing in the location of either the threatening (spider) or non-threatening (cat) stimulus. Results demonstrated an initial threat-relevant bias in the 200 ms exposure condition, which disappeared at stimulus durations of 500 ms, and reversed in the opposite direction at 2000 ms. Taken together, these results suggest that attentional avoidance may represent a significant component in cognitive vulnerability to anxiety.

Interpretive Biases

Although theories differ in their emphasis of various stages of attentional processing, they generally agree that individual differences in attention to threat-relevant material is integral to our understanding of anxiety (e.g., Beck & Clark, 1997). Many researchers further argue that differences in information processing are also reflected in the way that people interpret stimuli. In line with this assumption, research has shown that anxious individuals tend to interpret ambiguous stimuli or events as negative or threatening (e.g., Amir et al., 2005; Eysenck, Mogg, May, Richards, & Mathews, 1991). For example, when provided with ambiguous sentences, participants with a clinically diagnosed anxiety disorder were more likely to provide threatening (as opposed to non-threatening) interpretations compared to recovered clinically anxious and never anxious samples (Eysenck et al., 1991). This finding is consistent with Beck’s (Beck, 1967) schema theory, which posits that threat-relevant schemata direct cognitive processing in anxious individuals.

Drawing on these findings, recent research has employed inventive paradigms to manipulate interpretive bias in clinical and non-clinical samples with the goal of testing the hypothesis that this bias plays a *causal* role in the development of pathological anxiety (see MacLeod, Campbell, Rutherford, & Wilson, 2004). The majority of experiments in this area has provided support for the assumption that anxiety vulnerability may be attributable, at least in part, to threat-relevant interpretive biases (e.g., Mathews & Mackintosh, 2000; Mathews, Ridgeway, Cook, & Yiend, 2007; Salemink, van den Hout, & Kindt, 2007c). However, Salemink, van den Hout, and Kindt (2007b) found that, although interpretive training appeared successful at inducing negative and positive biases, these biases were marginally linked to measures of state anxiety, but not to anxiety vulnerability per se. Additionally, despite the earlier contention that interpretive bias is learned implicitly (e.g., Mathews & Mackintosh, 2000), Salemink et al.'s results suggest that explicit knowledge of emotional valence of the stimuli presented during training mediates the relations between training, interpretive bias, and mood. Specifically, participants who were aware that they were being asked to consistently disambiguate statements in a particular direction (e.g., negative) showed stronger interpretive biases. These findings suggest that although interpretive training may be effective at an explicit level, its effects on less conscious processing is unknown.

Automatic vs. Strategic Processing

Although there is overwhelming evidence supporting the existence of threat-relevant cognitive bias in anxiety (e.g., Williams, Mathews, & MacLeod, 1996), there remains controversy in the literature regarding whether attention and interpretation are automatic or strategic processes (Beck & Clark, 1997; Mathews, 2004; Matthews & Wells, 2000; McNally, 1995). As described by Bargh (1994), automatic processes are those which are unconscious, unintentional, uncontrollable, and efficient in their use of cognitive resources. In contrast, strategic processes (referred to as controlled by Bargh) are conscious, intentional, controllable, and inefficient in their use of cognitive resources.

In their information processing model, Beck and Clark (1997) propose a chronological distinction between automatic and strategic processes in attention to anxiety-provoking stimuli. These researchers argue that initial orientation to threat is entirely automatic in that stimuli are processed involuntarily and outside of consciousness, while consuming few attentional resources. The function of this *early warning detection system* is to identify biologically threat-relevant stimuli and assign these stimuli a processing priority. Furthermore, this system may operate so quickly that it classifies stimuli solely as threatening or safe, without registering specific content (e.g., Mathews & MacLeod, 1994). Beck and Clark refer to a second stage of processing as *immediate preparation*, activating the so-called primal mode, which is defined as a group of interrelated mental representations related to survival. This primal mode is functionally similar to the engagement stage, as described in the current article. Beck and Clark contend that this stage involves both automatic and strategic processes, because the process is rapid and involuntary and functions strategically to appraise the threat level of the stimulus. Finally, Beck and Clark posit a third stage, termed *secondary elaboration*. They describe this stage as primarily strategic, as the individual attempts to cope effortfully with the stimulus-driven anxiety through a variety of methods (e.g., avoidance, reinterpretation of the stimulus as nonthreatening). Continued processing of the stimulus, however, may still be automatic in nature (Beck & Clark, 1997).

Following from Beck and Clark’s (1997) model of anxiety, researchers have attempted to empirically disentangle automatic and strategic components of information processing in anxiety. As pointed out by McNally (1995), however, it is difficult, if not impossible, to develop a process-pure measure of attention, as extant paradigms (e.g., e-Stroop, dot-probe, visual cueing, visual search) readily require a mix of both automatic and strategic processes (see also Sherman et al., 2008). As such, experiments purporting to assess automatic and strategic information processing in anxiety have either relied on the assumption that time-course of responding (e.g., responses to stimuli presented at different durations) reflects concrete differences in automatic and strategic processing (e.g., Amir, Coles, & Foa, 2002), or utilized mathematical modeling procedures to estimate the relative contributions of automatic and strategic processes (e.g., McNally, Otto, Hornig, & Deckersbach, 2001).

The utility of separating the realm of cognitive processes into automatic and strategic seems questionable, as such a distinction may conflate important differences between qualitatively distinct processes (Sherman et al., 2008), in the present case: orientation, interpretation, engagement, disengagement, and avoidance. Moreover, the characteristics of automaticity do not always covary (Moors & De Houwer, 2006), and mental functions and behaviors often involve features of both automaticity and control (e.g., Bargh, 1992; Sherman et al., 2008). For example, a task like typing may be described as automatic for a skilled typist, in that it occurs effortlessly without conscious awareness of how fingers quickly move from one letter to the next. This behavior, however, is almost definitely intentional (i.e., purposely initiated by the typist) and controllable (i.e., stoppable once initiated). In line with this contention, McNally (1995) argued that, although threat-related attention biases may be involuntary (in terms of both initiation and control) and unconscious, they do not appear to be resource-free or effortless. Given the unique roles of orientation, interpretation, engagement, disengagement, and avoidance, it may be more useful to take the qualitatively distinct nature of these processes into account instead of forcing them into the distinction between automatic and strategic processes. At the same time, relating the underlying nature of these processes to basic mechanisms of human information processing may provide a parsimonious, integrative framework that could guide future research and intervention. In the reminder of this article, we discuss the potential of contemporary dual-systems models in providing such a framework. Specifically, we propose a multi-process model of cognitive vulnerability to anxiety that relates each of the previously identified processing stages to the distinction between associative and rule-based processes. Drawing on this model, we outline how individual differences in the two processes may contribute to cognitive vulnerability to the anxiety disorders, and what implications these considerations have for research and treatment.

Dual-Systems Models

In recent years, several dual-systems models have been advanced within the social-cognitive literature (e.g., Gawronski & Bodenhausen, 2006; Lieberman, 2003; Sloman, 1996; Smith & DeCoster, 2000; Strack & Deutsch, 2004). These models posit two distinct systems of processing which operate in tandem to problem-solve, make social judgments, regulate emotions, and influence evaluative responses. These systems, often referred to as associative and rule-based, are conceptualized as mechanistic in nature, and are believed to explain cognitive operations across a broad spectrum of functioning. The central difference between the two systems is rooted in their operating principles. Whereas the processing of information in the associative system is characterized by rapid activation of associated concepts via spreading activation (*associative processing*), information processing in the rule-based system involves the rational analysis of factual relations between concepts (*rule-based processing*). Until now, the distinction between associative and rule-based processing has been successfully applied to social behavior (Strack & Deutsch, 2004), attitude formation and change (Gawronski & Bodenhausen, 2006), cognitive vulnerability to depression (Beevers, 2005; Haeffel et al., 2007), memory in PTSD (Brewin et al., 1996), and the development of addictive behaviors (Wiers et al., 2007). In the remainder of this article, we argue that the basic tenets of dual-systems models may also help elucidate the nature of cognitive biases within the anxiety disorders.

Associative and Rule-Based Processes

Information processing in the associative system is characterized by the activation of associated concepts via spreading activation. According to Sloman (1996), the associative system organizes mental representations on the basis of similarity and temporal contiguity. However, the truth or accuracy of the links between concepts is not analyzed within the associative system (Gawronski & Bodenhausen, 2006; Strack & Deutsch, 2004). Such validation processes are assumed to occur in the rule-based system, which is concerned with the truth or accuracy of the information activated in the associative system. Examples include the activation of social stereotypes associated with gender, race, age, or other obvious physical characteristics. When encountering a woman, for instance, traits such as warm, caring, sensitive, and timid may come to mind immediately without an explicit appraisal of the accuracy of these traits as descriptions of this particular woman.

In contrast to the associative system, information processing in the rule-based system can be described as the rational analysis of factual relations between concepts on the basis of symbolic reasoning and syllogistic inference. Thus, one of the most central characteristics of rule-based processes is their concern with validity (Gawronski & Bodenhausen, 2006; Strack & Deutsch, 2004). For instance, Strack and Deutsch (2004) argued that activated links in the associative system (e.g., activated associations between the concepts *spiders* and *dangerous*)[2] serve as the basis of corresponding propositions in the rule-based system (e.g., "*spiders are dangerous*"), which assesses the veracity of these propositions by means of syllogistic inferences. According to Gawronski and Bodenhausen (2006), truth or falsity is assessed on the basis of logical consistency, such that inconsistency within the set of momentarily considered propositions serves as a marker of inaccuracy. If the momentarily considered set of propositions is consistent, these propositions can be regarded as valid, and therefore be used as a basis for judgments and behavioral decisions. If, however, the momentarily considered set of propositions is inconsistent, the veracity of these propositions has to be regarded as questionable, in that at least one of them may be inaccurate. In this case, the truth or falsity of each proposition has to be reassessed until consistency prevails. In most circumstances, consistency is achieved by rejecting (i.e., reversing the truth value of) at least one of the involved propositions (e.g., Gawronski, Peters, Brochu, & Strack, 2008; Gawronski & Strack, 2004).

According to Gawronski and Bodenhausen (2006), such inconsistency-related rejections are the primary reason for dissociations between associative and rule-based processes. For instance, rejecting or negating the proposition "*spiders are dangerous*" as a result of rule-based processing may lead to a reduction in the explicit endorsement of that proposition (e.g., in a self-report measure). However, merely negating (i.e., assigning a negative truth value to) this proposition in the rule-based system does not necessarily deactivate the underlying link between *spiders* and *dangerous* in the associative system (e.g., Deutsch, Gawronski, & Strack, 2006; Gilbert, 1991; Strack & Deutsch, 2004). To the contrary, negations in the rule-based system often lead to paradox or ironic effects in the associative system, such that negating the relation between two concepts enhances rather than reduces the strength of their associative link. In line with this assumption, Gawronski, Deutsch, Mbirkou, Seibt, and Strack (2008) found that repeated negations of social stereotypes enhanced rather than reduced the strength of stereotypical associations; a significant reduction occurred only when participants repeatedly affirmed the counterstereotype. These findings are in line with earlier demonstrations of rebound or ironic effects, showing that suppression of behavioral responses often enhance the very behaviors that are meant to be avoided (e.g., Macrae, Bodenhausen, Milne, & Jetten, MA; for a review, see Wegner, 1994).

Determination of Behavior

In their Reflective-Impulsive Model (RIM), Strack and Deutsch (2004) contend that behavior is jointly influenced by the associative and rule-based systems. In the associative system, behavior is the product of behavioral schemata that are activated via processes of spreading activation. These schemata are assumed to elicit spontaneous behavioral tendencies that have been described as impulsive (Strack & Deutsch, 2004) or reflexive (Lieberman, 2003). In contrast, behavior generated by the rule-based system is the product of decision processes, which “choose” subjectively appropriate actions by integrating information about the value and the probability of their consequences (Strack & Deutsch, 2004). Such actions generated by the rule-based system are typically described as reflective (Lieberman, 2003; Strack & Deutsch, 2004).

If the impulsive tendencies generated by the associative system are incompatible with reflective decisions generated by the rule-based system, self-regulatory conflicts may occur (Strack & Deutsch, 2004). In such cases, a person's motivation and ability to engage in effortful processing will dictate which system "wins the race." For instance, if a person possesses limited cognitive resources because of stress, distraction, or stimulus overload, he or she may be less able to engage in rule-based analyses of the available information. Similarly, the associative system will prevail over the rule-based system if a person's motivation to engage in effortful processing is low. In such cases, behavior is primarily determined by the associative system, such that behavioral schemata that are associated with momentarily activated concepts will drive responses. If, however, motivation and ability to engage in effortful processing is high, behavioral decisions generated by the rule-based system may override impulsive tendencies generated in the associative system, leading to a superiority of the rule-based system over the associative system in determining behavior. In addition, behavior determination by the two systems is modulated by arousal, such that rule-based processing will be undermined if arousal is either relatively low or extraordinarily high (Strack & Deutsch, 2004). Moreover, impulsive tendencies generated by the associative system will be particularly strong if arousal is high (Hull, 1943). As such, behavior determination by rule-based processing is likely to peak at intermediate levels of arousal, whereas both high and low levels of arousal will enhance behavior determination by the associative system (Strack & Deutsch, 2004).

A Multi-Process Model of Cognitive Vulnerability to Anxiety

Current information processing models of anxiety differ in their focus on orientation (e.g., Mogg & Bradley, 2002), engagement (e.g., Bradley et al., 2000), disengagement (Fox et al., 2001; 2002), avoidance (e.g., Koster et al., 2007), and interpretation (e.g., Teachman, 2005). Additionally, researchers attempting to explain differences in processing stages have largely focused on the distinction between automatic and strategic processes (e.g., Amir et al., 2002; Beck & Clark, 1997). As outlined earlier in this article, the distinction between automatic and strategic processes may be suboptimal in providing a clear understanding of the processes that underlie cognitive biases in the anxiety disorders. In the following sections, we propose a multi-process model of cognitive vulnerability to anxiety, which is based on the distinction between associative and rule-based processes advanced by dual-systems models (see Figure 1). Our central claim is that individual differences in the two kinds of processes may be responsible for cognitive biases at different stages of processing threat-relevant stimuli, thereby contributing to the development and maintenance of various types of anxiety disorders.

Orientation

In line with the basic principles of dual-systems models (e.g., Gawronski & Bodenhausen, 2006; Lieberman, 2003; Sloman, 1996; Smith & DeCoster, 2000; Strack & Deutsch, 2004), our model assumes that encountering a given stimulus (e.g., a red spot on the wall) activates corresponding concepts in the associative system. To the degree that these concepts are associatively linked with threat-related concepts, safety-oriented behavioral schemata will be activated, which includes the immediate orientation toward the threatening stimulus. Thus, a central individual difference factor at this initial stage of processing is the strength of associations between a stimulus and threat-relevant concepts. For example, the associative network of an individual diagnosed with OCD likely contains strong links between contamination-related stimuli (e.g., blood, disease, germs) and concepts related to threat and danger, which in turn activate anxiety-related, biologically fundamental behavioral responses (i.e., attentional orientation).

Orientation responses can be regarded as unintentional, in that they do not require any intention for their initiation. In addition, immediate orientation responses do not require conscious awareness of the threatening stimulus, as shown by research using subliminal, masked stimuli (e.g., Mogg, Bradley, & Hallowell, 1994). However, attentional orientation seems to capture at least a minimum amount of cognitive capacity, as implied by research using the e-Stroop. These studies have demonstrated that orientation to threat-relevant stimuli can interfere with other cognitive processes (e.g., color-naming), suggesting that at least some cognitive resources are captured by the threatening stimuli (McNally, 1995).

Interpretation

A central assumption in several dual-systems models is that the two systems operate in parallel (e.g., Strack & Deutsch, 2004). Thus, if a stimulus spontaneously activates corresponding concepts in the associative system, the rule-based system will immediately use the inputs from the associative system to interpret and appraise that stimulus. To the degree that these inputs include threat-related associations, the stimulus will be interpreted as threatening. Thus, threat-related associations again serve as an important individual difference factor at the interpretation stage, such that interpretations of a given stimulus as threatening are enhanced as a function of increasing strength of these associations.

Even though interpretation is often regarded as a strategic process in the anxiety literature (e.g., Eysenck et al., 1991; Teachman, 2005), we believe that interpretation is more accurately described as a rule-based process that includes features of both automaticity and strategy. From the perspective of dual-systems models, the propositional categorization of a stimulus as threatening or non-threatening involves the assignment of a truth value to a proposition about a state of affairs (e.g., "*this object or situation is threatening*"), thereby representing a rule-based process in terms of its definition (Strack & Deutsch, 2004). Still, interpretation processes are based on inputs from the associative system, such that enhanced activation of threat-related associations contribute to the interpretation of a given stimulus as threatening. This conceptualization is in line with research in the areas of social prejudice and impression formation, showing that the interpretation of ambiguous behavior (e.g., facial expressions) is biased by chronic associations related to the group membership of the target (e.g., Hugenberg & Bodenhausen, 2003). Moreover, even though the actual interpretation of a stimulus seems to involve a conscious process, the biasing influence of activated associations on how that stimulus is interpreted seems to occur outside of conscious awareness (e.g., Gawronski, Geschke, & Banse, 2003). Moreover, interpretation processes are often unintentional, in that they are initiated spontaneously by inputs from the associative system. Yet, interpretation processes can be regarded as controllable, as an initial interpretation can always be invalidated in the light of additional information (see below). Finally, interpretation processes do not seem to require a large amount of cognitive capacity, at least as long as the inputs from the associative system unambiguously support a particular interpretation (see Chun, Spiegel, & Kruglanski, 2002).

These considerations can be easily applied to interpretation biases in the anxiety disorders. For example, an individual with PTSD will quickly orient towards stimuli that activate threat-related associations. Importantly, threat-related associations may sometimes be activated by an ambiguous stimulus that is superficially similar to a threat-relevant object or situation, even though the stimulus itself does not belong to the category of threatening objects (e.g., the sound of a car backfiring activating threat-related concepts associated with war trauma). These threat-related associations may then provide the input for an immediate interpretation of the stimulus as threatening (e.g., interpretation of the ambiguous stimulus as a gunshot). These assumptions are consistent with research showing that anxiety is related to and perpetuated by a tendency to interpret ambiguous stimuli as threatening (e.g., Yoon & Zinbarg, 2007).

Engagement

Following the onset of orientation responses, threat-related associations in the associative system will enhance attentional engagement with the stimulus parallel to the process of interpreting that stimulus. Thus, in addition to their effects on orientation responses and interpretation biases, individual differences in threat-related associations contribute to anxiety-related biases by means of their influence on attentional engagement. Such engagement responses are most likely conscious, in that individuals may consciously experience their engagement with the stimulus. Still, attentional engagement may often occur unintentionally, such that engagement is elicited by the associative system without the individual's intention to attend to the stimulus. Interestingly, engagement with threatening stimuli seems to capture a significant amount of cognitive resources (Gawronski, Deutsch, & Strack, 2005). Using a dual-task paradigm, Gawronski et al. demonstrated that stimuli that were evaluatively incongruent with participants' motivational orientation (i.e., approach vs. avoidance) captured more attentional capacity than did motivationally congruent stimuli. However, this effect was qualified by the valence of the stimuli, such that residual capacity varied as a function of motivational orientations only for positive but not for negative stimuli. Instead, negative stimuli captured a large amount of attentional capacity irrespective of participants' motivational orientation. Given that the majority of negative stimuli used in Gawronski et al.'s study can be regarded as threat-related (e.g., spiders, knives, accidents), these results suggest that attentional engagement with threatening stimuli may capture a significant amount of cognitive resources.

An important question in this context concerns the controllability of engagement responses. According to the logic of dual-systems models, enhanced engagement with a stimulus will likely increase the activation of corresponding associations, implying a positive feedback loop with rather dysfunctional consequences (e.g., "freezing") in the case of threat-related associations (see Dandeneau, Baldwin, Baccus, Sakellaropoulo, & Pruessner, 2007). That is, activation of threat-related associations enhances attentional engagement with a threatening stimulus, which in turn increases the activation of threat-related associations (see Figure 1). Thus, to overcome this dysfunctional feedback loop, an individual will have to overcome the attentional effects of the associative system and disengage from attending to the stimulus. In other words, the challenging task for the rule-based system is to disrupt the aforementioned feedback loop by either (a) directly deactivating threat-related associations in the associative system or (b) executing a behavioral response that moves the individual's attention away from the threatening stimulus. Whereas the first case is reflected in what we call (in)validation, the second case is equivalent to attentional avoidance, which, in combination with the engagement response generated by the associative system, determines success or failure at attentional disengagement.

Validation and Avoidance

If a stimulus is interpreted as threatening, this initial interpretation may become the subject of rule-based validation processes that may either confirm or disconfirm the veracity of this interpretation. Drawing on assumptions by Gawronski and Bodenhausen (2006), we argue such validation processes involve at least three different cases, all of them producing unique psychological outcomes.

First, an individual may affirm the threatening nature of the stimulus (e.g., "*my heart rate is increasing, and it's dangerous when my heart rate increases*"). In this case, behavioral decisions generated in the rule-based system will often lead to attentional avoidance of the stimulus in order to reduce the continuous activation of threat-related associations caused by the stimulus. However, affirmation of the threatening nature of the stimulus will likely enhance the activation of threat-related associations, which in turn enhances attentional engagement with the stimulus. As such, affirmation of threat will produce a response conflict (Strack & Deutsch, 2004), such that it promotes attentional engagement via its effects on the associative system, but attentional avoidance via its effects within the rule-based system. As we argue below, such response conflicts represent the core of anxiety-related impairments in attentional disengagement.

Second, an individual may negate the threatening nature of the stimulus (e.g., "*my heart rate is increasing, but it's not dangerous when my heart rate increases*"). In this case, rule-based decisions to avoid attention to the anxiety provoking stimulus may be reduced. Moreover, negation of threat-related concepts in the rule-based system (e.g., "*increases in heart rate are not dangerous*") may not necessarily lead to a deactivation of their underlying associations in the associative system (e.g., associations between the concepts *increased heart rate* and *dangerous*). Instead, rule-based negation may in fact lead to ironic effects in the associative system, such that negating the link between two concepts enhances rather than reduces associations (e.g., Gawronski, Deutsch, Mbirkou, Seibt, & Strack, 2008). As such, negation of the threatening nature of a stimulus will fuel the dysfunctional feedback loop of attentional engagement and threat-related associations in two ways. First, negation of threat-related associations will directly enhance the activation of these associations. Moreover, enhanced activation will increase attentional engagement with the threatening stimulus which, in turn, enhances the activation of threat-related associations. Second, behavioral decisions not to avoid attention to the stimulus will likely enhance the activation of threat-related associations (by means of attending to that stimulus). Enhanced activation, in turn, will increase attentional engagement, which further enhances the activation of threat-related associations. As such, negating the threatening nature of stimulus will likely increase rather than decrease fearful responses (see Wegner, 1994).

Third, the threatening stimulus may be reinterpreted using a different category, which is equivalent to notion of reappraisal. If the new interpretation implies that the stimulus or situation is safe (e.g., "*my heart rate is increasing just because it's hot in here*"), behavioral decisions to avoid attention to the stimulus are likely reduced. However, in contrast to threat negation, the new interpretation of the stimulus may effectively deactivate threat-related associations (e.g., Gross, 1998; Mitchell, Nosek, & Banaji, 2003; Wheeler & Fiske, 2005), thereby reducing attentional engagement. Importantly, reduced attentional avoidance resulting from rule-based processes is unlikely to enhance the dysfunctional feedback loop of attentional engagement and threat-related associations, as the activation threat-related associations by the stimulus is effectively disrupted via reappraisal of that stimulus. As such, the most effective strategy in overcoming fear responses via rule-based processes is reappraisal of the stimulus, whereas negation of threat will lead to paradox or ironic effects (Wegner, 1994).

Disengagement

Several models of anxiety-related attentional bias suggest that impaired disengagement plays a significant role in the etiology and maintenance of anxiety disorders (e.g., Amir et al., 2003; Fox et al., 2001). According to our model, impaired attentional disengagement does not represent a separate stage in the sequence of processing threat-related stimuli. Instead, we argue that impaired disengagement is a joint product of (a) enhanced engagement responses elicited in the associative system and (b) ineffective avoidance responses generated in the rule-based system. Put differently, we argue that impaired disengagement reflects a response conflict between an impulsive tendency to attend to a threat-related stimulus and a behavioral decision to move one's attention away from that stimulus.

The notion of response conflicts in attentional disengagement may be illustrated with the typical setup in visual search tasks. As outlined earlier, disengagement in visual search tasks is measured by comparing detection times on trials where the participant has to find a neutral target among threatening distracters to trials where both targets and distracters are neutral. To verify the presence of the target, participants need to quickly move their attention from one stimulus to the next, if it has been acknowledged that the earlier stimulus is not the target. Such decisions to shift one's attention can be described as rule-based, as they reflect a voluntarily initiated decision that is based on a verified state of affairs (i.e., "*the current stimulus is not the target*"). Impulsive tendencies generated in the associative system can interfere with these behavioral decisions, if these tendencies promote attentional engagement. For instance, threat-related associations may activate an impulsive tendency to attend to a given stimulus, and this tendency may interfere with the decision to move one's attention away from that stimulus to the next one in the array. From this perspective, attentional disengagement does not represent a separate stage of the attentional sequence that is conceptually distinct to the engagement stage. Instead, impaired disengagement reflects a conflict between engagement responses elicited by the associative system and avoidance responses generated by the rule-based system.

Applied to our multi-process model (Figure 1), such antagonistic response tendencies, leading to impaired disengagement, are particularly likely when a given stimulus activates threat-related associations. These associations are assumed to elicit an impulsive tendency to pay attention to the stimulus (i.e., engagement), which may then interfere with a person's decision to move his or her attention away from that stimulus (i.e., avoidance). In real-life situations, this decision is likely based on the person's insight that continued attention to the stimulus may perpetuate the fear response (via continued activation of threat-related associations), which in turn may promote a conscious decision to avoid attention to the stimulus (see Hariri, Mattay, Tessitore, Fera, & Weinberger, 2003; Pessoa, Kastner, & Ungerleider, 2002; Taylor, Phan, Decker, & Liberzon, 2003). In other words, the ease or difficulty of attentional disengagement is jointly determined by (a) the strength of attentional engagement elicited by the associative system and (b) the voluntary attempt to avoid attention to the stimulus generated by the rule-based system (Mathews, Yiend, & Lawrence, 2004). To the degree that anxiety disorders are more strongly associated with enhanced difficulty in attentional disengagement (rather than enhanced engagement), our model suggests that cognitive vulnerability to anxiety is most likely due to an interactive effect of associative and rule-based processes, which by themselves may be insufficient to produce pathological forms of anxiety.

According to dual-systems theories of behavior, the behavioral impact of rule-based processes is reduced under conditions of either low motivation or low cognitive capacity. In addition, associative processes are likely to prevail over rule-based processes in behavior determination under conditions of either high or low arousal (Strack & Deutsch, 2004). These considerations have important implications for response conflicts resulting from associative and rule-based processes. For instance, anxious responses are often associated with high levels of arousal, which should enhance impulsive behavioral tendencies generated in the associative system. Moreover, recent evidence suggests that individual differences in working memory capacity moderate the relative impact of associative and rule-based processes on overt behavior (Hofmann, Gschwendner, Friese, Wiers, & Schmitt, 2008). For individuals with high working memory capacity, behavior was more strongly determined by rule-based as compared to associative processes, whereas individuals with low working memory capacity showed stronger influences of associative than rule-based processes. Thus, in combination with these findings, our model points to three individual difference factors that may jointly determine cognitive vulnerability to anxiety: (a) strong threat-related associations, (b) high levels of arousal associated with the threatening stimulus, and (c) low levels of working memory capacity.

Implications for Research and Intervention

Our multi-process model not only provides a conceptual integration of cognitive biases in the anxiety literature; it also identifies potential sources of cognitive vulnerability to anxiety, which may become the target of clinical interventions. The most significant components in this regard are: (a) the activation of threat-related associations, (b) the invalidation of threat via reappraisal, and (c) the effectiveness of executive control.

Association Activation

According to our multi-process model, threat-related associations represent a critical factor in the reduction of cognitive biases that may contribute to the development and maintenance of anxiety disorders. Important insights in this regard can be derived from recent research using implicit measures of automatic associations to study processes of attitude change (for a review, see Gawronski & Bodenhausen, 2006). One conclusion that can be drawn from this research is that different types of manipulations are differentially effective in changing automatic evaluative associations in the associative system versus evaluative judgments derived from rule-based inferences. For instance, whereas cognitive dissonance (see Festinger, 1957) has been shown to be more effective in changing evaluative judgments compared to evaluative associations (e.g., Gawronski & Strack, 2004; Wilson, Lindsey, & Schooler, 2000), evaluative conditioning procedures (see De Houwer, Thomas, & Baeyens, 2001) seem more effective in changing evaluative associations than evaluative judgments (e.g., Gawronski & LeBel, 2008; Gibson, 2008; Olson & Fazio, 2006). According to Gawronski and Bodenhausen (2007), this differential effectiveness is due to the match versus mismatch between the nature of the manipulation and the nature of the affected process. For instance, Gawronski and Strack (2004) argued that cognitive dissonance is an inherently propositional phenomenon, which makes it more effective in changing propositional judgments generated in the rule-based system. In contrast, repeated pairings of a neutral conditioned stimulus (CS) with either a positive or negative unconditioned stimulus (US) may directly affect the structure of associations in memory, making it more effective in changing evaluative associations (Gawronski & LeBel, 2008). Thus, treatments that combat threat-related associations via lower-level associative processes (e.g., repeated pairings of anxiety-provoking stimuli with positive valence) may be more effective in changing these associations compared to treatments that emphasize conscious insights into the harmlessness of threat-relevant objects (e.g., education that innocuous changes in physical sensations are common).

Cognitive Behavior Therapy (CBT) is currently the treatment of choice for the majority of anxiety disorders (CBT; see Norton & Price, 2007). We argue that our multi-process model is useful not only for understanding the effectiveness of CBT, but for refining its underlying components. For instance, exposure to a feared stimulus in contexts that produce positive outcomes may weaken threat-related associations by creating threat-unrelated, positive associations. In a similar vein, repeated success in a previously feared environment may create a new link between the feared stimulus or context (e.g., driving) and a positive emotion (e.g., pride). Finally, merely approaching a threatening stimulus may create positive associations, which in turn may reduce fearful responses (e.g., Teachman & Woody, 2003). The latter assumption is consistent with recent research in social-cognitive psychology, showing that repeated approach responses to negative objects can change negative associations related to these objects (e.g., Kawakami, Phills, Steele, & Dovidio, 2007; Woud, Becker, & Rinck, 2008).

Invalidation of Threat

Another potential target of intervention is the invalidation of threat-related associations. As outlined above, different kinds of invalidation strategies seem differentially effective in disrupting the dysfunctional feedback loop between association activation and attentional engagement. Whereas reappraisal seems quite effective in reducing the activation of threat-related associations, negation may actually enhance rather than reduce the activation of threat-related associations (e.g., Gawronski et al., 2008; see also Gross, 1998). These insights have important implications for the effectiveness of interpretive training on anxiety (e.g., Mathews & Mackintosh, 2000; Salemink et al., 2007c; Salemink, van den Hout, & Kindt, 2007b). Specifically, our model suggests that the choice of language may be particularly important in the process of invalidating threat. For example, reappraising a spider as “harmless” is likely to activate the dimension of harm (e.g., Park, Yoon, Kim, & Wyer, Jr., 2001), and may therefore produce ironic activation effects equivalent to the ones resulting from negations. Instead, the reappraisal of a spider as "safe" seems more likely to lead to reduced activation of threatening concepts. Given that it is seems much easier to generate positive adjectives for feared stimuli such as dogs (e.g., cute, cuddly, friendly) or physical sensations (e.g., excitement) than for evolutionarily prepared fearful stimuli (e.g., spiders, heights, germs), reappraisal training may be more effective in reducing anxiety disorders for the former compared to the latter categories.

Resembling the notion of reappraisal, cognitive techniques often emphasize rule-based strategies (e.g., third-person perspective taking, analysis of consequences) to examine alternative responses to feared stimuli. Particularly important in these contexts may be the particular focus that is adopted in the cognitive restructuring of the fear response. As outlined above, research in the social-cognitive area suggests that enhanced training in negating threat-relevant associations (e.g., "*increases in heart rate are not dangerous*") may actually have an ironic effect on the activation of these associations. A more functional strategy may be the affirmation of alternative associations, which has been shown to effectively reduce the activation of unwanted associations (Gawronski et al., 2008).

Executive Control

An important factor that, to our knowledge, has received only limited attention to date is the role of executive function in vulnerability to anxiety disorders. At least two lines of research are relevant in this regard. First, recent research by Hofmann et al. (2008) has shown that individual differences in working memory capacity moderate the relative impact of activated associations and rule-based inferences on overt behavior. For participants with high working memory capacity, behavior was influenced more strongly by rule-based inferences compared to activated associations, whereas the opposite occurred for participants with low memory capacity (see also Thush et al., 2008). To the degree that working memory capacity is a critical factor in overcoming the dysfunctional feedback loop of activated associations and attentional engagement, individual differences in working memory capacity may represent a crucial determinant in cognitive vulnerability to anxiety. Consistent with this idea, researchers have demonstrated relationships between trait anxiety and impaired central executive functioning (Eysenck, Payne, & Derakshan, 2005), and pre-combat IQ and PTSD risk (e.g. McNally & Shin, 1995; Macklin et al., 1998). Particularly relevant to our model, research has shown that worry interferes with performance on tasks assessing executive function (Crowe, Matthews, & Walkenhorst, 2007) and working memory (Hayes, Hirsch, & Mathews, 2008). Moreover, in a sample of older adults diagnosed with GAD, participants who committed at least one error on the Mini-Mental State Exam (Folstein, Folstein, & McHugh, 1975) evidenced higher levels of symptom severity at baseline. Worry, therefore, may play a specific role within our model for individuals diagnosed with GAD, such that it perpetuates the dysfunctional feedback loop of activated associations and attentional engagement by reducing working memory capacity, thereby inhibiting disengagement ability.

Second, research by Sherman et al. (2008) suggests that the effectiveness of executive control over unwanted responses can be enhanced, and that such improvements may in fact occur during CBT. Using a multinomial modeling procedure (Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005) to reanalyze data from Teachman and Woody (2003), Sherman et al. found that treatment-related reductions in phobic reactions to spiders were associated with enhanced success at overcoming threat-related associations (rather than genuine reductions in threat-related associations per se). These results suggest that (a) the execution of behavioral decisions in the rule-based system plays a significant role in the reduction of anxiety, and (b) the effectiveness of this process can be enhanced via CBT. In terms of our multi-process model, one possible mediator of such influences may be reduced levels arousal over the course of treatment, which should modulate the relative strength of threat-related associations and rule-based inferences in determining behavioral responses (see Strack & Deutsch, 2004). Future research investigating the cognitive underpinnings of enhanced executive control via CBT may help to further improve currently available treatment methods.

Conclusion

Based on a review of cognitive biases in anxiety, we presented a multi-process model of cognitive vulnerability to anxiety, which integrates the available evidence on anxiety-related biases in orientation, interpretation, engagement, disengagement, and avoidance. Drawing on the core assumptions of contemporary dual-systems models (e.g., Gawronski & Bodenhausen, 2006; Lieberman, 2003; Sloman, 1996; Smith & DeCoster, 2000; Strack & Deutsch, 2004), we argued that differences in associative and rule-based processes may account for individual differences in cognitive vulnerability to anxiety. A central implication of our model is that the development and maintenance of anxiety disorders is jointly determined by the strength of threat-related associations and the particular strategy employed to invalidate threat-related associations. In addition, we identified individual differences in executive functioning (e.g., working memory capacity) as a potential factor that may contribute to cognitive vulnerability to anxiety. Thus, by linking anxiety-related symptoms to basic principles of information processing, our multi-process model parsimoniously integrates different kinds of cognitive biases in anxiety, providing a useful framework for future research and clinical intervention.

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Footnotes

1 As one reviewer thoughtfully pointed out, we present a vulnerability model, as opposed to a model of psychopathology. Although a vulnerability model is harder to test, because it necessitates the monitoring of at-risk populations over time, we nevertheless believe that theoretically, individual differences in associative and rule-based processing contribute to both the etiology and maintenance of anxiety disorders. Moreover, the research cited in the current review has utilized clinical, non-clinical, and subclinical (i.e., at risk) samples varying in levels of state anxiety, trait anxiety, disorder-specific symptomatology, and clinical diagnostic category, providing support for our contention that a vulnerability model is indeed justified.

2 As one reviewer pointed out, some researchers have focused on the role that disgust plays in the etiology and maintenance of some anxiety disorders, as opposed to (or in addition to) fear (e.g., Moretz & McKay, 2008; Mulkens, de Jong, & Merckelbach, 1996; Olatunji et al., 2007; Teachman, 2006). Although it could be argued that this would necessitate specific components in our model to account for disgust, current models of emotion define core affect as the result of elevations (or reductions) on the dimensions of pleasure/displeasure and arousal (Russell, 2003). As such, to the extent that disgust and fear function as different types of core affect, the properties of the proposed model should account for the effects (and indeed the influences on) both. For a more detailed discussion of models of emotion, see Smith and Neumann (2005) and Russel (2003).

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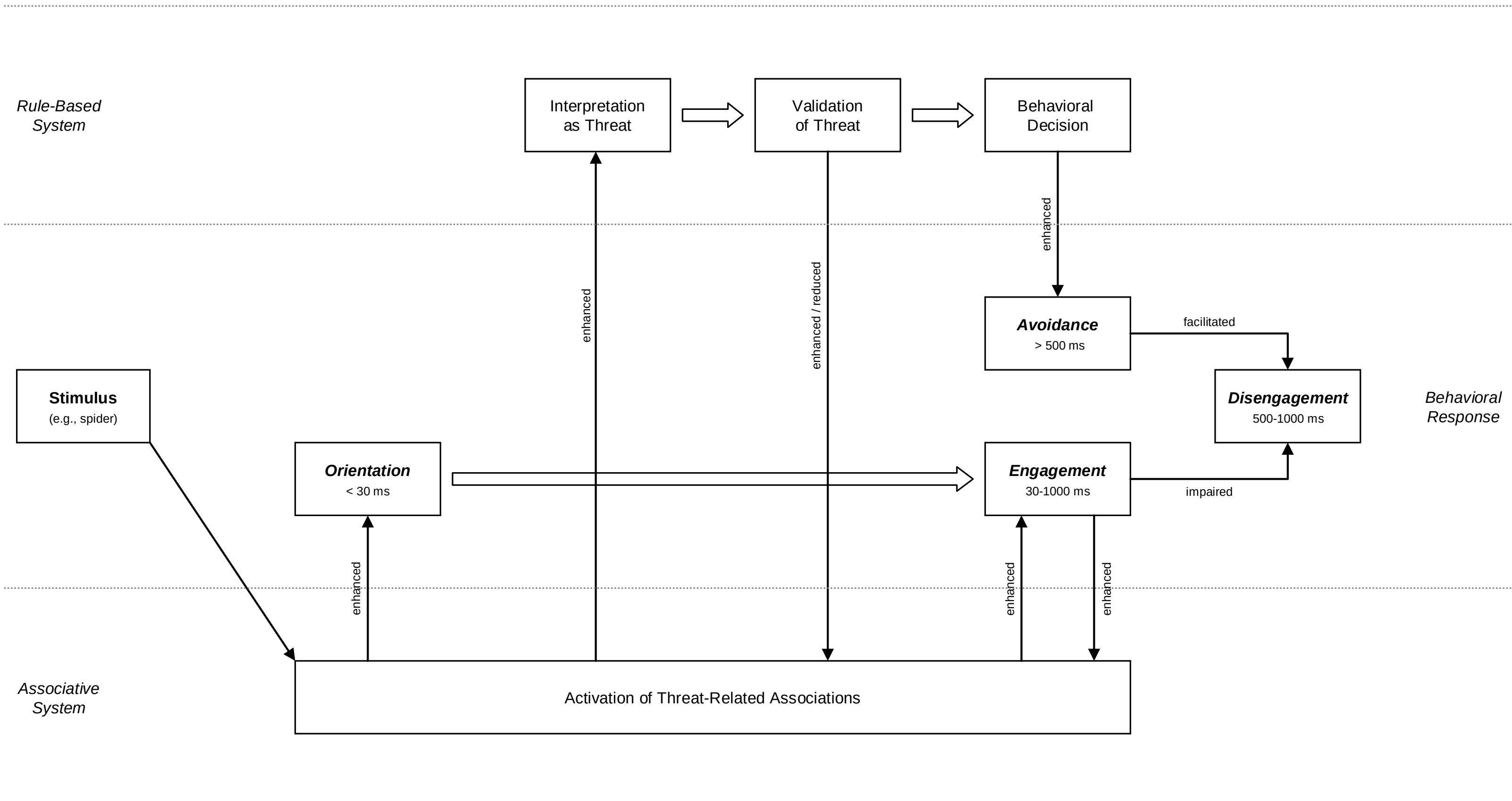
Figure Caption

Figure 1. Multi-process model of cognitive vulnerability to anxiety. Boxes in the upper and lower panels depict processes in the associative and rule-based systems, respectively; the panel in the middle depicts behavioral responses generated by the two systems; arrows indicate hypothesized influences between processes and effects on behavior.


Rule-Based System
Interpretation as Threat
Validation of Threat
Behavioral Decision
enhanced
enhanced / reduced
enhanced
Avoidance
> 500 ms
facilitated
Disengagement
500-1000 ms
Behavioral Response
Stimulus
(e.g., spider)
Orientation
< 30 ms
Engagement
30-1000 ms
impaired
enhanced
enhanced
enhanced
Associative System
Activation of Threat-Related Associations