The Cognitive Basis of Trait Anger and Reactive Aggression: An Integrative Analysis

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Cognitive processing approaches to personality have gained momentum in recent years, and the present review uses such a cognitive approach to understand individual differences in anger and reactive aggression. Because several relevant cognitive models have been proposed in separate literatures, a purpose of this review is to integrate such material and evaluate the consistency of relations obtained to date. The analysis reveals that processes related to automatic hostile interpretations, ruminative attention, and effortful control appear to be important contributors to individual differences in angry reactivity. Memory accessibility processes, by contrast, failed to exhibit a consistent relationship with trait anger. This review concludes with the proposal of an integrative cognitive model of trait anger and the discussion of several broader issues, including the developmental origins of cognitive processing patterns and plausible links to temperament-based perspectives.

Keywords: *trait anger; reactive aggression; attention; accessibility; interpretation; effortful control; personality*

High levels of trait anger are associated with a variety of adverse consequences. The most frequently studied and highlighted of these consequences involves an increased likelihood of aggressive behavior (e.g., Berkowitz, 1993; Deffenbacher, 1992). Such systematic relations have been repeatedly documented in laboratory studies of aggression (Bettencourt, Talley, Benjamin, & Valentine, 2006). Also, trait anger is a wide and robust predictor of aggression outside of the laboratory, including its correlates related to aggressive driving behavior (e.g., Deffenbacher, Lynch, Oetting, & Yingling, 2001), aggression in the workplace (Douglas & Martinko, 2001), domestic violence (e.g., Barbour, Eckhardt, Davison, & Kassinove, 1998), and child abuse (e.g., Nomellini & Katz, 1983). From a public safety perspective, then, it is important to understand the underpinnings of trait anger.

Beyond its relevance to aggressive behavior, high trait anger also has a negative impact on physical, social, and psychological health variables. For example, high trait anger is perhaps the most robust personality-related predictor of cardiovascular disease (T. W. Smith, Glazer, Ruiz, & Gallo, 2004; J. E. Williams et al., 2000; J. E. Williams, Nieto, Sanford, Couper, & Tyroler, 2002). Moreover, high-trait-anger individuals are prone to engage in a variety of problematic health behaviors, including tobacco use (e.g., Spielberger, Foreyt, Goodrick, & Reheiser, 1995), excessive alcohol intake (Liebsohn, Oetting, & Deffenbacher, 1994; Litt, Cooney, & Morse, 2000), and unhealthy eating habits (e.g., Anton & Miller, 2005). From a physical health perspective, then, it is important to understand the basis of trait anger as well.

Many other adverse outcomes could be highlighted. Trait anger is clearly detrimental to interpersonal relationships (e.g., Baron et al., 2007; T. Q. Miller, Markides, Chiriboga, & Ray, 1995). Also, extreme levels of anger are a central feature of many psychological disorders, including several axis I disorders (e.g., intermittent explosive disorder, post-traumatic stress disorder, and major depression) and axis II disorders (e.g., borderline, paranoid, and narcissistic personality disorders) (American Psychiatric Association, 1994). As such, a more in-depth understanding of trait anger is also important from a

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psychological health perspective. Accordingly, the present review seeks to advance our knowledge of the underpinnings of trait anger.

A Cognitive Perspective

In general terms, cognition involves the set of processes that mediate between stimulus and response (Pashler, 1998; Sanders, 1998). Such processes include those related to attention, memory, interpretation, and self-regulation, all of which have been linked to specific processing circuits in the brain (e.g., Gazzaniga, 2004; Posner & Raichle, 1994). The prominence of the cognitive approach to trait anger is reflected in several literatures. In the clinical literature, for example, cognitive processes are often thought to underlie problematic levels of anger and reactive aggression, and treatments based on this cognitive perspective have been shown to be effective (e.g., A. T. Beck, 1999; R. Beck & Fernandez, 1998; Deffenbacher, Dahlen, Lynch, Morris, & Gowensmith, 2000).

It is also notable that social-psychological (e.g., Anderson & Bushman, 2002; Berkowitz, 1990) and developmental (e.g., Crick & Dodge, 1994) frameworks for understanding anger and aggression have primarily adopted a cognitive perspective. These models share the central premise that the manner in which a person cognitively processes hostile situational input is a major determinant of that person's angry and aggressive response to such situations. Many studies have been conducted in relation to these proposals, and they have converged on a set of possible cognitive mechanisms for individual differences in angry reactivity.

Despite such theoretical and empirical advances, it must be pointed out that different cognitive models emphasize different processing substrates (e.g., interpretation vs. memory accessibility). It is also true that relevant empirical work is scattered across several subdisciplines of psychology, including social/personality psychology (e.g., Cohen, Eckhardt, & Schagat, 1998), clinical/forensic psychology (e.g., P. Smith & Waterman, 2003), neuropsychology (e.g., Blair, 2001, 2004), and developmental psychology (e.g., Crick & Dodge, 1996). For these reasons, it is useful to take a wider perspective on the cognitive processing basis of trait anger by considering theories and findings from different literatures. Such a broader consideration can support wider conclusions than would be possible within a more narrow literature review.

As such, we sought to provide an integrative review of the various psychological literatures related to trait anger and reactive aggression. After making some necessary clarifications and distinctions, we begin by providing an overview of the pertinent cognitive theories (Section 1). Subsequent to this, we consider potential links between trait anger and the cognitive processes of attention, memory accessibility, interpretation, and effortful control (Section 2). We then review research focused on integrating these disparate processes into a comprehensive cognitive model of trait anger (Section 3). Finally, we discuss additional issues that can better situate our conclusions within models of temperament, developmental precursors, and the social consequences of trait anger (Section 4).

Definitions, Distinctions, and Trait Considerations

It is necessary to first review several distinctions that are commonly made in the literature. The first distinction is between state and trait anger. Spielberger (1988) defined state anger as "an emotional state marked by subjective feelings that vary in intensity from mild annoyance or irritation to intense fury and rage" (p. 1). Trait anger, however, involves stable individual differences in the frequency, duration, and intensity of state anger (Deffenbacher, 1992; Spielberger, 1988). With regards to this distinction, the current review focuses on trait anger and upon whether cognitive mechanisms can be useful in understanding why high-trait-anger individuals are more prone to state anger.

Another distinction commonly made in the literature involves anger and aggression. Anger is an internal feeling state that is typically associated with an increased motivation to hurt others. By contrast, aggression pertains to the actual act of hurting others. This distinction holds at both the state and trait level. Although manipulations of state anger increase the likelihood of aggression (Bushman & Anderson, 1998), other factors can intervene to dissociate this relationship (Bushman, Baumeister, & Phillips, 2001; DeWall, Baumeister, Stillman, & Gailliot, 2007). The adult personality literature has also found that trait anger and trait aggression load onto separate, but highly correlated factors (e.g., Buss & Perry, 1992; Costa, McCrae, & Dembroski, 1989; Martin, Watson, & Wan, 2000). The current review focuses on trait anger rather than trait aggression. However, some lines of inquiry initially linked particular cognitive processes to trait aggression but eventually found the relevant processes to be more directly linked with individual differences in anger (e.g., Dodge, 1980; Graham, Hudley, & Williams, 1992). In such cases, our review will reflect this historical progression.

It is perhaps less than fortunate that different researchers have used different measures to assess trait anger. Social/personality researchers have used several different measures of trait anger (e.g., Buss & Perry, 1992; Spielberger, 1988), as well as measures of the closely related construct of trait irritability (Caprara, 1983). However, it is important to point out that psychometric work has demonstrated that all such measures are

strongly correlated with each other and likely to tap the same latent construct (e.g., Martin et al., 2000). Such considerations suggest that findings involving one trait anger scale are likely to replicate with another scale (see Wilkowski, Robinson, Gordon, & Troop-Gordon, 2007, for an illustration).

Other researchers, mostly concentrated in the developmental literature, have made the distinction between reactive and proactive aggression (e.g., Dodge & Coie, 1987). Individuals who tend to aggress out of anger have been labeled as *reactive* aggressors (e.g., Dodge & Coie, 1987). Individuals who aggress not out of anger, but rather to aid in goal pursuit, have been labeled as *proactive* aggressors (e.g., Dodge & Coie, 1987). This reactive-proactive distinction has considerable support at the trait level (see Blair, 2001, 2004; Crick & Dodge, 1994, 1996; Dodge & Coie, 1987).

Although trait anger and trait reactive aggression might appear to be subtly different constructs, we could locate no psychometric research supporting such a subtle distinction. Furthermore, in examining these measures, it is apparent that trait anger scales often reference reactive aggression (e.g., "When I get mad, I say nasty things"; Spielberger, 1988), and that reactive aggression scales often reference anger (e.g., "This child overreacts angrily to accidents"; Dodge & Coie, 1987). Moreover, trait anger is a robust predictor of reactive aggressive behaviors (see Bettencourt et al., 2006, for a review), and trait reactive aggression predicts indices of the angry emotional reaction to provocation (Hubbard et al., 2002). Thus, despite the possible differences between trait anger and reactive aggression, the similarities are far more apparent. Considering such similarities, the current review will also focus upon measures of reactive aggression. As we shall see, there is a strong tendency for parallel cognitive patterns to emerge in relation to these two constructs (e.g., Crick & Dodge, 1996; Epps & Kendall, 1995).

We also review some data related to the cognitive correlates of the Big 5 trait of agreeableness. This is an important inclusion because trait researchers have increasingly embraced the Big 5 model of personality, which can provide a consensual reference scheme for the major individual difference variables (John & Srivastava, 1999; McCrae & Costa, 1999). Within such models, trait anger is often conceptualized in terms of low levels of agreeableness (e.g., Ahadi & Rothbart, 1994; Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993), and there are multiple sources of data to support this view (e.g., Jensen-Campbell & Graziano, 2001; Meier & Robinson, 2004; Watson, 2000). Yet it is also true that agreeableness taps a wider range of facets than does trait anger (e.g., sympathy & helping; Digman & Takemoto-Chock, 1981; Goldberg, 1990). Thus, although recognizing that agreeableness is likely to tap a larger variety of cognitive processes than trait anger, it seemed important to include agreeableness-related studies to the extent that they are centrally related to the hostile reactivity processes of interest here. Fortunately, as our review will document, there are data suggesting important parallels in the cognitive correlates of agreeableness and trait anger.

1. SOCIAL-COGNITIVE THEORIES

Social-cognitive views of personality suggest that individuals primarily differ in how they respond to particular types of situations (e.g., Mischel & Shoda, 1995). This meta-theoretical framework is quite applicable in the realm of trait anger, in that high-trait-anger individuals are more reactive to hostile situational input (e.g., provocation or insult) than are low-trait-anger individuals. This is true in relation to the dependent measures of state anger (Deffenbacher, 1992), cardiovascular arousal (T. W. Smith, 1992; T. W. Smith et al., 2004), and aggressive behavior (Bettencourt et al., 2006). Trait anger does not tend to predict these variables strongly in the absence of hostile situational input (Bettencourt et al., 2006; Deffenbacher, 1992; T. W. Smith et al., 2004). Broadly speaking, then, it is important to understand why it is that high-trait-anger individuals are so much more reactive to hostile situational cues.

Social-cognitive theories suggest that the manner in which one cognitively processes hostile situational input is a strong determinant of one's reaction to that situation. In this vein, Dodge and Crick's Social Information Processing (SIP) theory (e.g., Crick & Dodge, 1994; Dodge, 1991; Dodge & Crick, 1990) has been one of the most generative models in understanding individual differences in such reactivity processes. According to this developmental theory, two stages of information processing are seen as relevant to hostile reactivity. The first stage involves attending to and encoding hostile cues in the situation. The second stage involves forming a more global interpretation of the overall situation. Hostile biases at either stage of information processing are seen as predisposing one toward increased anger and reactive aggression. Research pertaining to these two processes is systematically reviewed below (see Sections 2.1, 2.3, 3.1, 3.2).

Berkowitz's (1990, 1993) Cognitive Neo-Associationistic theory has been especially influential in the adult social/personality literature on anger and reactive aggression. The central focus of this model is on spreading activation processes. Related thoughts, memories, and feelings are proposed to be linked together in an associative network. When any one component of this network is activated (e.g., by viewing a weapon), activation is

presumed to spread to related concepts. To the extent that hostile thoughts tend to be evoked by this process of spreading activation, tendencies toward anger and reactive aggression are facilitated. Stable individual differences in the functioning of this associative network could therefore be of relevance to trait anger, and research relevant to this proposal will be reviewed in Section 2.2.

The General Aggression Model (GAM) was originally proposed by Anderson, Deuser, and DeNeve (1995) but has been extended considerably in recent years (e.g., Anderson & Bushman, 2002; Anderson & Carnagey, 2004). Echoing Berkowitz's theory (1990, 1993), the GAM suggests that spreading activation processes are a primary contributor to anger and aggression. Two additional proposals of the GAM also guided our review. Bushman (2002) proposed that a prolonged focus on hostile information can increase the intensity and duration of angry feelings, a process here termed *ruminative attention* (reviewed in Sections 2.1 and 3.2). Additionally, the GAM suggests that there are two stages involved in the interpretation process, one of which is early and automatic and the other of which occurs later and is controlled. Without elaborating excessively at this point, we point out that our review will focus on this distinction between early and late interpretation processes (see Section 3.1).

Theories of anger and aggression frequently posit that self-regulation processes may also be important to consider in understanding trait anger. Too often, though, theorists have failed to clarify the nature of such processes in a cognitively tractable manner. However, developmental psychologists have provided a clear definition for a construct termed *effortful control*, which relates to individual differences in the capacity to inhibit dominant processes in favor of subdominant processes (Rothbart, 1989). Moreover, they suggest that effortful control plays a major role in the self-regulation of one's tendencies toward anger and aggression (e.g., Posner & Rothbart, 2000). Research related to this theoretical framework is presented in Sections 2.4 and 3.3.

In summary, then, theoretical models have proposed that a number of cognitive processes are relevant to individual differences in anger and reactive aggression, including processes related to attention, memory accessibility, interpretation, and effortful control. However, these theories frequently differ in the specific processes they emphasize. Moreover, it is apparent that these cognitive processes may not be monolithic in nature and should be broken down in terms of component subprocesses (e.g., automatic and controlled aspects). Our goal, then, is to integrate these diverse strands of theory and data into a unified cognitive model of the processes contributing to trait anger and reactive aggression.

2. A REVIEW OF THE EMPIRICAL LITERATURE

In Section 2, our goal is to provide an integrative review of the cognitively oriented trait anger research that has emerged from several different subdisciplines of psychology. We review such material in separate sections pertaining to the particular cognitive process of interest.

2.1. Selective Attention

William James (1890) observed that the perceptual environment consists of an almost bewildering array of sights and sounds and that the human mind seems ill equipped to process such numerous inputs in a thorough and complete manner. From this perspective, attention processes play a crucial role in determining which sources of information are selected for processing, thereby determining which sources of information shape subsequent consciousness and behavior (Pashler, 1998). According to Dodge's (1991) SIP model and, to a certain extent, Anderson and Bushman's (2002) GAM, selective attention processes favoring hostile information should lead to increased levels of trait anger.

Recently, several studies have been conducted along these lines. One set of studies has used the emotional Stroop task, in which a participant is asked to ignore a stimulus's meaning and simply name the color it is displayed in. Delays in color naming are taken as an indication of the allocation of attention to a particular stimulus type (J. M. G. Williams, Mathews, & MacLeod, 1996). Six studies have demonstrated that high-trait-anger individuals appear to pay more attention to hostile stimuli, as evidenced by slower responses in naming the color of hostile stimuli. Effects of this type have been found using angry facial expressions (Putman, Hermans, & van Honk, 2004; van Honk, Tuiten, de Haan, van den Hout, & Stam, 2001) and hostile words (Eckhardt & Cohen, 1997; P. Smith & Waterman, 2003, 2005; van Honk, Tuiten, van den Hout, et al., 2001).

In recent years, however, concerns have been raised about the emotional Stroop task and what it is measuring (see Algom, Chajut, & Lev, 2004; De Houwer, 2003). For this reason, cognition-emotion researchers have increasingly embraced spatial measures of attention, which are more unambiguous in nature (Mogg & Bradley, 1998). Trait anger researchers have also used such spatial attention measures and have found that trait anger is systematically related to hostile biases in attention within these tasks as well. Two such studies have used a visual search paradigm to assess hostile biases in attention (Cohen et al., 1998; P. Smith & Waterman, 2004). In these studies, it was found that participants high in trait anger (Cohen et al., 1998) and violent criminals (P. Smith & Waterman, 2004) had difficulty ignoring distracting hostile stimuli.

This was indicated by slower responses to locate a neutral target word when it was surrounded by hostile distracter words.

Additional studies have established similar trait-linked biases using spatial probe tasks. In these tasks, words (either hostile or nonhostile in nature) are briefly presented and then replaced by spatial probes. To the extent that attention is drawn toward hostile cues, participants should be quicker to respond to probes replacing hostile words. Using variations on this paradigm, it has been found that violent criminals (P. Smith & Waterman, 2003), high-trait-anger individuals (P. Smith & Waterman, 2003), and individuals low in agreeableness (Wilkowski, Robinson, & Meier, 2006) pay more attention to hostile stimuli. This is indicated by faster responses to probes replacing hostile stimuli. Results from these studies thus complement other attention-related paradigms in suggesting that high-trait-anger individual preferentially attend to hostile stimuli.

2.2. Memory Accessibility

The accessibility of information within memory has been a central focus of social psychological research for decades (DeCoster & Claypool, 2004). Prominent models (e.g., Higgins, 1989) suggest that related concepts (e.g., "doctor" and "nurse") are stored closer together in semantic memory, explaining why preexposure to one word speeds the recognition of a conceptually related word (Neely, 1991). In the cognitive literature, it is quite clear that such priming effects are important to understanding the manner in which semantic knowledge is stored and retrieved (McRae & Boisvert, 1998; Neely, 1991; Shelton & Martin, 1992).

Moreover, this spreading activation framework appears to work well in understanding situational influences on anger and aggression (Anderson & Bushman, 2002). For example, priming blame-related concepts leads to increased state anger (Meier & Robinson, 2004, Study 2; Neumann, 2000). Similarly, social-cognitive work has shown that preexposure to weapons or media violence increases the accessibility of hostile thoughts, as well as the likelihood of aggressive behavior (e.g., Anderson, Benjamin, & Bartholow, 1998; Anderson & Bushman, 2001). The success of this social-cognitive model of situational influences has led several theorists to offer the reasonable suggestion that memory accessibility processes may prove useful in understanding individual differences in anger and aggression as well (e.g., Anderson & Bushman, 2002; Berkowitz, 1993; Todorov & Bargh, 2002). However, inconsistencies have led us to question the importance of accessibility processes in understanding trait anger.

At a conceptual level, the precise manner in which trait anger would be related to accessibility of hostile thoughts is unclear, and one can entertain at least three distinct possibilities. First, high-trait-anger individuals could have *chronically accessible* hostile thoughts (e.g., Todorov & Bargh, 2002). This view suggests that high-trait-anger individuals would be faster to recognize hostile stimuli regardless of situational primes. A second view suggests that individuals high in trait anger have stronger interconnections between hostile thoughts in memory (Berkowitz, 1993). If so, preexposure to a hostile prime should be more likely to speed the recognition of a hostile target at high levels of trait anger. A third possibility is that hostile concepts are linked to a wide variety of concepts (including nonhostile concepts) at high levels of trait anger. This proposal leads to the suggestion that hostile situational priming effects would be *less* consequential at high levels of trait anger (Meier, Robinson, & Wilkowski, 2007). These different views of possible relations between trait anger and accessible hostile thoughts renders it important to be clear and specific concerning what one means by "accessible" hostile thoughts.

Multiple methodologies have been used to assess the chronic accessibility of hostile thoughts, including those related to listing trait terms (Higgins, 1996) or reaction times related to encoding hostile words (Lindsay & Anderson, 2000). It is not clear that such diverse measurement procedures will converge on similar conclusions. More damning here is the fact that the vast majority of studies attempting to link reaction time measures of chronic accessibility to trait anger/irritability have failed to do so (Anderson, 1997, Study 2; Anderson, Anderson, & Deuser, 1996, Study 1; Anderson, Carnegey, & Eubanks, 2003, Studies 3 and 5; Anderson & Dill, 2000, Study 2; Lindsay & Anderson, 2000, Study 2; Meier & Robinson, 2004, Study 1-2; Meier et al., 2007, Studies 1-3; Wilkowski & Robinson, 2007, Studies 3-4; Wilkowski et al., 2006, Studies 1-2). Indeed, we could locate only two studies in which such a straightforward relationship was obtained using a reaction time task (Anderson et al., 2003, Study 4; Parrott, Zeichner, & Evces, 2005). Overall, then, it is difficult to endorse the straightforward view that high-trait-anger individuals have "chronically accessible" hostile thoughts, defined in cognitive terms.

Instead, trait anger could predict stronger priming effects from one hostile thought to another. In the cognitive literature, such priming effects would be examined in tasks in which a hostile word is briefly flashed before another hostile word. The critical question is whether preexposure to one word speeds the recognition of a related word (McRae & Boisvert, 1998; Neely, 1991). We are unaware of any studies showing that individuals high in trait anger exhibit stronger interconnections between their hostile thoughts in such purely cognitive tasks. However, other studies have used a

hybrid approach in which the "prime" involves preexposure to a more extended episode, such as watching a violent film (e.g., Lindsay & Anderson, 2000). It is unclear whether such extended-duration priming paradigms are closely related to priming effects in semantic memory, which typically involve short-duration spreading activation processes (McRae & Boisvert, 1998; E. R. Smith, 1990).

Leaving aside such methodological considerations, results are inconsistent. Five studies using the "hybrid" approach (Anderson & Dill, 2000, Study 2; Anderson et al., 1996, Study 1; Anderson et al., 2003, Studies 3-5) found no relationship between trait irritability and the priming of hostile thoughts. Lindsay and Anderson (2000, Study 2) found a complex interaction that also depended on manipulated levels of pain prior to the cognitive task. Other data indicate that individuals high in trait anger/irritability display smaller hostile priming effects in studies using both the hybrid and traditional cognitive approach (Anderson, 1997, Study 2; Meier et al., 2007, Studies 1-3). In sum, it is simply very problematic to suggest that trait anger is closely related to the accessibility of hostile thoughts on the basis of cognitive data collected to date.

2.3. Interpretation

Beyond attention- and memory-related processes, it is intuitive to suggest that high-trait-anger individuals are prone to interpret ambiguous situations in a hostile manner. In fact, this suggestion is common to numerous theories, including appraisal and attribution theories of emotion (e.g., Lazarus, 1991; Weiner, 1986), SIP (Crick & Dodge, 1994), and the GAM (Anderson & Bushman, 2002). Even Berkowitz, who has frequently expressed skepticism concerning the role of interpretation processes in anger (e.g., Berkowitz & Harmon-Jones, 2004), ultimately takes the stance that whereas hostile interpretations are not necessary to create anger, they nonetheless will increase anger to the extent that they occur (Berkowitz, 1990, 1993).

The seminal work in this area was conduced within the developmental SIP tradition (for a review, see Crick & Dodge, 1994). Dodge (1980) first asked aggressive and nonaggressive children to interpret a number of situations involving one person harming another. These situations involved either clearly hostile intent (i.e., a deliberate act of aggression), clearly nonhostile intent (i.e., an accident), or ambiguously hostile intent (i.e., could be a deliberate act or an accident). Dodge found that aggressive and nonaggressive children differed in how they interpreted the ambiguously hostile actions in particular, with aggressive children perceiving more hostile intent. In more clear-cut situations (i.e., clearly hostile and clearly nonhostile), both groups of children were capable of deciphering the true intent.

The biased interpretation of ambiguous situations has been termed the *hostile attribution bias* and has been replicated numerous times among children of different ages and nationalities (see Crick & Dodge [1994]; Orobio de Castra, Veerman, Koops, Bosch, & Monshouwer [2002] for reviews). Conceptually parallel hostile attribution biases have been observed among adult populations in which trait anger measures have been administered (e.g., Dill, Anderson, & Deuser, 1997; Epps & Kendall, 1995; Hall & Davidson, 1996). Research on the Big 5 trait of agreeableness also offers conceptual support for such an interpretation bias, in that agreeable individuals have been shown to interpret potential conflict situations in more benevolent terms (e.g., Graziano, Hair, & Finch, 1997; Graziano, Jensen-Campbell, & Hair, 1996).

Although early research focused on the link between interpretational biases and individual differences in aggression (e.g., Dodge, 1980), subsequent research has indicated that this interpretation bias appears to be most directly linked to individual differences in anger. Several sources of evidence support this conclusion. First, studies have found a direct link between these interpretational tendencies and trait anger (Epps & Kendall, 1995; see also Dill et al., 1997; Hall & Davidson, 1996; Wilkowski et al., 2007; Wingrove & Bond, 2005). Second, research has also shown that only reactive aggression is linked to the hostile attribution bias, whereas proactive aggression is not (Crick & Dodge, 1996; Dodge & Coie, 1987). Finally, it has been found that anger mediates the link between interpretational biases and aggression (Graham et al., 1992).

Of further importance, research has shown that interventions designed to reduce the hostile attribution bias are effective in lessening tendencies toward anger and aggression. Along these lines, Guerra and Slaby (1990) designed a treatment program to correct a variety of cognitive biases linked to aggression, including the hostile attribution bias. This program successfully reduced aggression. Later, Hudley and Graham (1993) designed a treatment program that specifically targeted the hostile attribution bias and found that this intervention reduced anger and aggression among children. Given the success of such interventions, it appears that the hostile interpretation bias has causal importance in understanding individual differences in anger and reactive aggression.

Although the link between trait anger and attributions of hostile intent appears quite sound, there are in fact a family of appraisal and/or attribution theories that might be relevant to this bias. For example, Weiner's (1986) theory states that anger is the result of attributing a harmful action to causes which are internal to the

provocateur and controllable by him/her. C. A. Smith and Lazarus (1990) instead emphasized appraisals of motivational relevance, motivational incongruence, and other-accountability. Additionally, Shaver (1985) presented a theory of anger in which blameworthiness is central. In all, there are a variety of shades of meaning that could possibly be related to the hostile attribution bias. In social psychological studies, there is evidence consistent with each of these views (e.g., C. A. Smith, Haynes, Lazarus, & Pope, 1993; Rudolph, Roesch, Greitemeyer, & Weiner, 2004). However, there is precious little research comparing these subtly different appraisal frameworks for anger, and seldom has this research clarified these issues in relation to trait anger specifically. As such, it may be important in the future to clarify the precise nature of the hostile interpretation bias from an appraisal/attributional perspective.

2.4. Effortful Control

The sections above focus on processes generally thought to operate in a relatively automatic fashion. Automatic processes are clearly relevant to understanding anger-reactivity, as our review makes clear. However, more controlled forms of cognition are also relevant because it has been proposed that individuals with superior *effortful control* abilities may be able to override their automatic tendencies toward anger and aggression (e.g., Eisenberg, Smith, Sadovsky, & Spinrad, 2004). Effortful control is a construct that reflects individual differences in the ability to override dominant cognitive tendencies in favor of sub-dominant tendencies (Eisenberg et al., 2004; Rothbart, 1989).

This construct has been most extensively studied in the developmental literature. Within this literature, studies have most frequently measured effortful control through observer reports given by a parent or a teacher (Calkins, Dedmon, Gill, Lomax, & Johnson, 2002; Eisenberg et al., 1996; Eisenberg, Fabes, Nyman, Bernzweig, & Pinuelas, 1994; Rothbart, Ahadi, & Hershey, 1994). Other studies, however, have used cognitive assessments designed to more directly assess a child's ability to override a dominant cognitive process (Gerardi-Caulton, 2000; Kochanska, Murray & Harlan, 2000). Regardless of the specific manner in which effortful control has been measured, the results have been consistent: Effortful control is associated with reduced levels of anger and aggression.

For example, effortful control is negatively correlated with behavioral signs of anger in frustrating situations (Calkins et al., 2002; Kochanska et al., 2000). It is also inversely correlated with observer-reported trait anger (Gerardi-Caulton, 2000; Rothbart et al., 1994) and observer-reported trait aggression (Eisenberg et al., 1996; Rothbart et al., 1994). Furthermore, studies have shown that children higher in effortful control use more adaptive coping strategies in potentially angering situations (Eisenberg et al., 1994). Agreeableness has also been theoretically linked to effortful control (Ahadi & Rothbart, 1994; Graziano & Eisenberg, 1997). The literature supports this position, in that there is a systematic relationship between higher levels of agreeableness and higher levels of effortful control (Cumberland-Li, Eisenberg, & Reiser, 2004; Jensen-Campbell et al., 2002).

Another literature, largely clinical in nature, has converged on parallel conclusions regarding the highly similar construct of *executive function*. Individuals with superior executive function are thought to be more capable of controlling tendencies toward anger and aggression (see Morgan & Lilienfield [2000]; Seguin & Zelazo [2005] for relevant reviews). This literature typically administers cognitive tasks in which dominant responses must inhibited in the support of task goals, as is true in the classic Stroop (1935) task. Although relevant findings in this literature have varied from study to study, meta-analytic conclusions are robust. Both criminals and psychopathic individuals display poorer performance in a wide variety of executive function tasks (Morgan & Lilienfield, 2000). Other data more directly link individual differences in executive function with measures of trait aggression (see Seguin & Zelazo, 2005) and with measures of reactive aggression in particular (Giancola, Moss, Martin, Kirisci, & Tarter, 1996).

A number of neurological lines of inquiry also point to the inverse relationship between trait anger and executive function. The prefrontal cortex is widely agreed to be the neural center of executive function and effortful control (e.g., E. K. Miller & Cohen, 2001; Posner & Rothbart, 2000). Neuroimaging studies have shown that individuals predisposed toward anger and reactive aggression exhibit reduced activity in these prefrontal regions (e.g., Volkow et al., 1995; Volkow & Tancredit, 1987). Some have suggested that individuals prone to anger have deficits within the orbitofrontal cortex (OFC) more specifically (e.g., Blair, 2001, 2004). This OFC-based model is consistent with neuroimaging (e.g., Dougherty et al., 2004; Goyer et al., 1994) and lesion studies (Grafman, Schwab, Warden, Pridget, & Brown, 1996; Pennington & Benneto, 1993) showing that reactive forms of aggression appear to be closely linked to deficiencies in OFC function, relative to other regions of the prefrontal cortex.

Reduced levels of the neurotransmitter serotonin have also been linked to increases in trait anger and reactive aggression (Carver & Miller, 2006; Depue, 1995). Moreover, it has been suggested that serotonin exerts its influence on trait anger by facilitating the neural processes involved in the effortful control of

anger (see Krakowski, 2003). Consistent with this perspective, it has been shown that low available serotonin is systematically associated with OFC-related deficits in clinical samples prone to reactive aggression (Siever et al., 1999; Soloff, Meltzer, Greer, Constantine, & Kelly, 2000). Also, trait anger has been linked to the TPH gene responsible for serotonin production (Manuck, Flory, Dent, Mann, & Muldoon, 1999; Rujescu et al., 2002) and to the 5-HTTLPR gene responsible for serotonin reuptake (Greenberg et al., 2000; Jang et al., 2001; Lesch et al., 1996). In all studies, lower levels of available serotonin have been linked to increased tendencies toward anger in dispositional terms.

In sum, recent sources of data link individual differences in anger and reactive aggression to performance data, neural regions, neurotransmitters, and genes associated with effortful control. In all cases, higher levels of effortful control are associated with lower levels of trait anger. Such a convergence of data leaves little doubt that individual differences in such abilities play a significant role in understanding trait anger, and we revisit and extend this view in Section 3.3.

3. TOWARD AN INTEGRATED THEORY

Section 2 reviewed a large number of studies related to the cognitive processes linked with trait anger and reactive aggression. The reviewed findings converged on the general perspective that high-trait-anger individuals (a) preferentially attend to hostile stimuli, (b) interpret ambiguous behaviors in a more hostile manner, and (c) exhibit impaired effortful control abilities. We also suggested that accessibility frameworks, which have been supported in relation to the situational influences on anger and aggression (see Anderson & Carnagey, 2004), appear to be an inadequate basis for understanding *individual differences* in anger and reactive aggression.

The present section seeks to build upon the material reviewed above while attempting to integrate it into a more comprehensive cognitive model of trait anger. We will point out that it is important to further differentiate subprocesses involved the interpretation bias (Section 3.1), the attention-related bias (Section 3.2), and the role of effortful control in anger-reactivity processes (Section 3.3). Of additional importance, we will be concerned with interrelations between cognitive biases linked to trait anger, which have previously received scant attention in the literature. Drawing upon this more focused review, we then propose an integrative cognitive model of trait anger (Section 3.4).

3.1. The Cognitive Basis of the Hostile Interpretation Bias

Theoretical accounts converge on the idea that tendencies to interpret the behavior of others in a hostile manner should contribute to trait anger. However, theories differ in how automatic or controlled they view this process to be (e.g., Anderson & Bushman, 2002; Berkowitz, 1993). There are also differing proposals regarding the potential cognitive antecedents of the hostile interpretation bias. Given social-cognitive data pointing to the role of accessible information in interpretation (DeCoster & Claypool, 2004), some have suggested that the chronic accessibility of hostile thoughts in memory leads to the hostile interpretation bias (e.g., Copello & Tata, 1990; Zelli, Huesmann, & Cervone, 1995). On the other hand, because the allocation of attention can also influence interpretation processes (e.g., Taylor & Fiske, 1978), some frameworks have suggested that attentional processes may lead to the hostile interpretation bias (e.g., Blair, 2003). Thus, it is unclear exactly how or when the hostile interpretation bias emerges. Accordingly, the purpose of this section is to clarify such issues on the basis of extant cognitive data.

Selective attention processes cannot explain the hostile interpretation bias. It is possible that tendencies to preferentially attend to hostile stimuli could create the hostile interpretation bias (Blair, 2003). In support of this point, we found quite a few studies linking selective attention processes to trait anger (see Section 2.1). However, these studies involved isolated visual cues (e.g., words on a computer screen) that bear little similarity to the integrated visual scenes we encounter in daily life. Such considerations are important because the cognitive scene perception literature has repeatedly shown that people extract "gist" interpretations of scenes before attending to any specific stimulus within that scene (e.g., VanRullen & Thorpe, 2001; Venturino & Gagnon, 1992). For example, people can identify that a particular scene is a kitchen before attending to any specific object in that scene, such as the sink, blender, dishwasher, and so on.

This scene-perception perspective is important here because it permits a temporal examination of possible relations between interpretations and selective attention processes. If biases in attention do lead to hostile interpretations, then high-trait-anger individuals should preferentially attend to hostile cues while viewing and interpreting ambiguously hostile scenes. However, if high-trait-anger individuals extract hostile gist interpretations before attending to specific hostile cues, a very

different pattern should emerge. In this regard, the scene perception literature tells us that initial gist interpretations are quite cursory in nature (Simons, 2000) and that subsequent cognitive processing is needed to elaborate upon and confirm such early interpretations. In doing so, individuals preferentially attend to information that is seemingly discrepant with their early gist interpretation (e.g., an octopus in a kitchen; Henderson & Hollingworth, 1999). Accordingly, if high-trait-anger individuals do extract a hostile gist interpretation early in scene processing, then they should exhibit subsequent difficulties reconciling that hostile gist interpretation with gist-incompatible cues (i.e., nonhostile cues). This should lead them to preferentially attend to *nonhostile* gist-incompatible cues while viewing and interpreting ambiguously hostile scenes.

Wilkowski et al. (2007) recently examined such issues by tracking participants' eye movements as they viewed and interpreted ambiguously hostile scenes. These scenes depicted a harmful action, but were ambiguous because one visual cue in the situation (e.g., an angry facial expression) suggested hostile intent, whereas another visual cue (e.g., a direction of motion) suggested nonhostile intent. Consistent with the idea that high-trait-anger individuals extract hostile gist interpretations at early stages of processing, results demonstrated that high-trait-anger individuals preferentially attended to *nonhostile cues* within these scenes. Furthermore, we note that additional studies reported in the trait anger literature have conceptually replicated this sort of pattern (P. Smith & Waterman, 2004; Wingrove & Bond, 2005). For example, Wingrove and Bond (2005) found that high-trait-anger individuals take longer to read a nonhostile resolution to an otherwise ambiguously hostile passage.

Although future research and replication is needed in this area, several suggestions nevertheless follow from the careful time-course analysis of Wilkowski et al. (2007). First and foremost, such data make it clear that attentional biases favoring hostile stimuli are not instrumental in creating the hostile interpretation bias. This is because high-trait-anger individuals appear to extract hostile "gist" interpretations of ambiguous scenes before attending to any specific stimulus in that scene. Moreover, attentional biases favoring hostile stimuli are not operative *during* the process of interpretation at all. Instead, high-trait-anger individuals appear to exhibit difficulties reconciling nonhostile cues with their initial hostile gist interpretation. As such, they actually pay more attention to nonhostile stimuli during interpretational processing. To the extent that attentional biases favoring hostile stimuli are important to understanding trait anger, then, it appears as though they must operate at a separate stage of processing than analyzed in the Wilkowski et al. (2007) study. Accordingly, Section 3.2 will consider the possibility that attentional biases toward hostile stimuli are operative at a point in time *after* interpretational processing is complete.

Dual-process explanations of the hostile interpretation bias. Our review suggests that the hostile interpretation bias is unlikely to relate to memory accessibility processes, which are not consistently linked to trait anger (Section 2.2). Moreover, the section immediately above suggests that the hostile interpretation bias is unlikely to be explained by selective attention. Instead, the hostile interpretation bias appears to occur very early in information processing. This is consistent with dual-process models of attribution. According to such models (Anderson & Bushman, 2002; Gilbert & Malone, 1995), early and automatic stages of dispositional inference assume that a person's behavior reflects his or her internal motivations and dispositional tendencies (e.g., assume that a harmful act was intentional). With sufficient motivation and available cognitive resources, subsequent controlled processing can correct for early mistakes in the attribution process.

Applying these dual-process models to the hostile interpretation bias, it may be that this bias first emerges at an automatic stage of information processing. In support of this point, we have reviewed evidence that individuals high in trait anger appear to extract hostile inferences at early stages of attention (Wilkowski et al., 2007). Other studies by Zelli and colleagues (Zelli, Cervone, & Huesmann, 1996; Zelli et al., 1995) further support this point, in that their results indicate that aggressive individuals are more likely to encode ambiguous behaviors as hostile in nature, even when given no instructions to form an impression. Subsequent studies have conceptually replicated this pattern with violent prison populations (Copello & Tata, 1990) and with direct measures of trait anger (Wingrove & Bond, 2005). Such data are important in demonstrating that the anger-linked hostile interpretation bias appears to be characteristic of very early processes of automatic inference.

Thus, it appears that the trait-linked hostile interpretation bias relies on automatic inference processes. However, dual-process models also suggest that, to the extent that one carefully analyzes the situation, high-trait-anger individuals might be able to correct for the biased nature of their spontaneous inferences. Indeed, there is evidence that this is the case. When individuals process information in a more careful and prolonged manner, the hostile interpretation bias is eliminated (Dodge & Newman, 1981). Similarly, studies have found that instructions to think about the situation from a more objective, third-person perspective also eliminate the hostile interpretation bias (Dodge & Frame, 1982; Sancilio,

Plumert, & Hartup, 1989). There are several indications in the literature that such a third-person perspective encourages the use of a more controlled form of information processing (e.g., Epstein & Pacini, 1999; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). In sum, there is evidence that the hostile attribution bias emerges at an early, automatic stage of processing, but can be corrected for with additional controlled processing.

Although data clearly indicate that high-trait-anger individuals are more likely to spontaneously encode ambiguous behaviors as hostile in nature (e.g., Zelli et al., 1996), there is an additional issue that would seem useful to examine in future studies. Attributions of hostility can potentially be linked to behaviors (i.e., a hostile action) or to people (i.e., a hostile person). Existing studies on trait anger and automatic attributions of hostility are viewed as ambiguous concerning the question of whether such inferences pertain to actions or to persons (see Zelli et al., 1995, 1996, for a discussion). More recent methodological innovations in the automatic trait inference literature (Skowronski, Carlston, Mae, & Crawford, 1998; Todorov & Uleman, 2002) may therefore be useful in clarifying the precise nature of these spontaneous hostile attributions.

3.2. Reconsidering the Role of Attentional Biases

Several social-cognitive models suggest that preferentially attending to hostile stimuli in the environment should lead to increased anger and reactive aggression (e.g., Bushman, 2002; Dodge, 1991), and the empirical literature clearly supports this position (see Section 2.1). However, theoretical models highlight different manners in which attentional biases could contribute to anger. One proposal is that individuals predisposed to anger and reactive aggressive might possess an early vigilance for hostile stimuli in the environment (e.g., Dodge, 1991) and that this could potentially feed forward to bias interpretations in a hostile direction (Blair, 2003). However, studies reviewed above suggest that the hostile interpretation bias is an early, automatic phenomenon that seems to occur prior to attending to specific cues in the situation.

An alternative proposal is that hostile biases in attention do not *create* hostile interpretations but rather reinforce the impact of preexisting hostile interpretations (e.g., Bushman, 2002). Such a proposal is quite consistent with the existing literature on rumination (e.g., Nolen-Hoeksema, 1991; Rusting & Nolen-Hoeksema, 1998). After all, rumination is defined in terms of the prolonged allocation of attention to negative information (Nolen-Hoeksema, 1991). Consistent with such an account, it has been found that individuals who report increased tendencies toward angry rumination exhibit higher levels of trait anger (Berry, Worthington, O'Connor, Parrott, & Wade, 2005; Linden, Hogan, Rutledge, Chawla, Lenz, & Leung, 2003; Martin & Dahlen, 2005; Sukhodolsky, Golub, & Cromwell, 2001). Moreover, such individuals also exhibit prolonged tendencies towards aggressive behavior following a provocation (Collins & Bell, 1997).

Although the latter studies have generally relied on self-reports of rumination, recent work has suggested that ruminative processes can be modeled in attention-related tasks (e.g., Wilkowski et al., 2006). For example, Siegel, Steinhauer, Carter, Ramel, and Thase (2003) found that a measure of the time to disengage attention from negative stimuli was clearly related to self-reported depressive rumination, as well as to depression itself. Such results are exciting because they suggest that ruminative processes can be assessed in more direct cognitive terms (see also Compton, 2000). It seems likely that this attention-related perspective on ruminative processes will also contribute to the literature on anger and aggression. Toward this end, Wilkowski et al. (2006) recently used a modified spatial probe task to illustrate that disagreeable individuals are slow to disengage attention from hostile stimuli *after* they had categorized such stimuli. Future research should seek to further link measures of trait anger to cognitive indices of attentional disengagement.

3.3. The Role of Effortful Control Processes

Both theory (Posner & Rothbart, 2000) and data (see Section 2.4) reveal that high levels of effortful control are associated with reduced trait anger. However, effortful control is a very general resource, and it seems that a more nuanced understanding of such processes might be useful. What is important, according to the present analysis, is not so much one's overall "level" of effortful control. Rather, what is important is whether such effortful control resources are successfully recruited and employed in situations where they are needed (i.e., in hostile situations; Wilkowski & Robinson, 2007). If such effortful control resources are allowed to lie dormant at such critical junctures, then they would be rather inconsequential for individual differences in anger (Mischel & Ayduk, 2004). Such an analysis should encourage researchers to investigate trait anger's relationship to the use of effortful control in hostile situations specifically.

A recent series of studies provides preliminary support for this view by showing that individuals high in agreeableness (Meier & Robinson, 2004) and low in trait anger (Wilkowski & Robinson, 2007) exhibit systematic dissociations between the activation of hostile thoughts and the resulting affect. For example, Meier

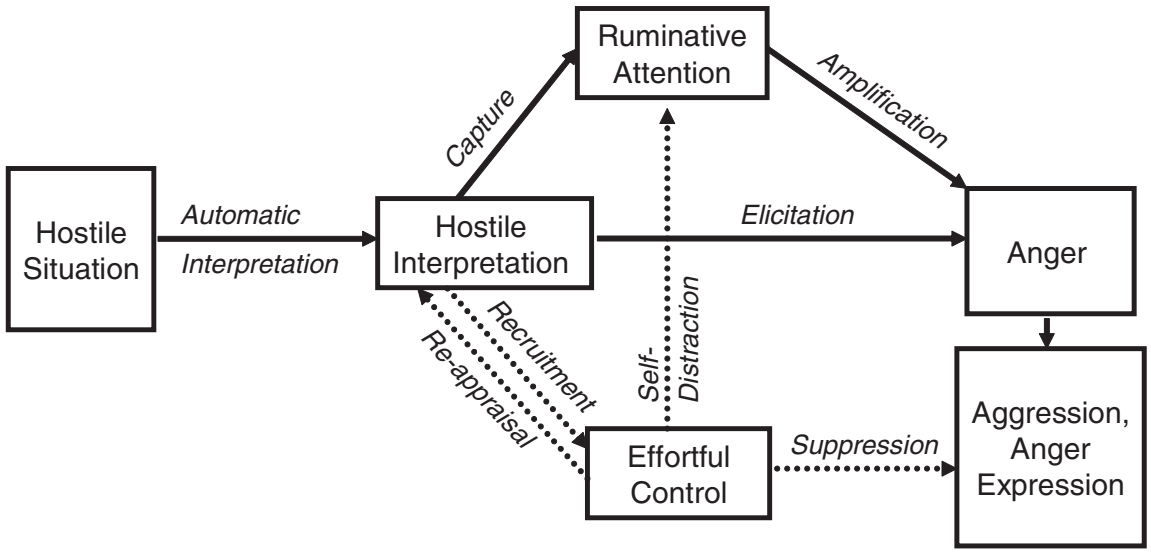

Figure 1 An integrative cognitive model of trait anger.

and Robinson (2004) found that a situational manipulation of blame accessibility increased state anger only among individuals low izn agreeableness. At high levels of agreeableness, the activation of blame-related thoughts was inconsequential. This is consistent with the idea that agreeable individuals recruit effortful control resources and use them to down-regulate their hostile thoughts (Meier & Robinson, 2004; Meier, Robinson, & Wilkowski, 2006).

In relation to trait anger specifically, several studies reported by Wilkowski and Robinson (2007) extend this situation-specific perspective of effortful control. In Study 2 of this work, hostile prime words consistently led high-trait-anger individuals to evaluate a subsequent target word more negatively. When allotted sufficient time, low-trait-anger individuals were capable of attenuating this bias. The imposition of time restrictions, however, rendered low- and high-trait-anger individuals equally susceptible to the biasing effects of hostile primes. Without sufficient time, then, it appears as though low-trait-anger individuals are unable to recruit effortful control resources and use them to correct for the biasing influence of hostile primes. Studies 3 and 4 of this work also supported a situation-specific effortful control perspective, in that low-trait-anger individuals exhibited decrements on a secondary task following the activation of hostile thoughts. This is consistent with the idea that limited capacity effortful control resources had been recruited for other purposes.

In sum, we suggest that effortful control resources are necessary but not sufficient for anger control. It is also important that such capacities for effortful control be specifically recruited in response to situations that are likely to provoke anger and aggression. In our current, ongoing investigations, we are seeking to test this conceptualization in a more direct manner.

3.4. An Integrative Cognitive Model

The material reviewed above sets the stage for an integrative cognitive model of trait anger. As indicated in Section 1, several cognitive models of anger and reactive aggression have been posited, but these models emphasize a variety of different cognitive processes. As indicated in Section 2, an integrative model should incorporate three stages of information processing that have been consistently linked to trait anger in previous research, namely, those associated with selective attention, interpretation, and effortful control. As indicated in Section 3, recent research has been important in explicating the temporal course of these anger-related biases as well as their interrelations. Based on such prior research and theory, we offer an integrative cognitive model of trait anger. It should be emphasized from the outset that this model is not meant to be definitive in nature. Rather, its goal is to parsimoniously integrate prior theory and data, thereby helping to organize and stimulate future cognitive research pertaining to trait anger.

Our model is depicted in Figure 1. Solid lines indicate processing pathways that increase anger, whereas dotted lines indicate processing pathways that reduce anger likelihood and intensity. At the broadest level, cognitive processes are seen as intervening between hostile situational influences and subsequent outputs related to

anger and aggression. In accordance with the material presented above, we suggest that high-trait-anger individuals are predisposed to interpret ambiguous situations in a hostile manner (see Section 2.3). This occurs at a very automatic level of information processing, and precedes all other documented processing tendencies (see Section 3.1).

Although individuals high in trait anger are more likely to interpret ambiguous situations in a hostile manner (see Section 2.3), some provocations are clear and unambiguous (e.g., an unprovoked assault). There is little doubt that all individuals will interpret such unambiguous situations as hostile (e.g., Dodge, 1980), leading to the elicitation of some initial experience of state anger even at low levels of trait anger (e.g., Graham et al., 1992). However, subsequent cognitive processing can either exacerbate or minimize tendencies toward anger following such hostile interpretations. Hostile information is proposed to automatically capture attention, much as negative information does in general (see Öhman, 1997; Pratto & John, 1991; Robinson, 1998). This capture of attention by hostile information leads, quite naturally, to rumination upon such information. To the extent that such a process is allowed to continue, it will tend to amplify existing anger and intensify propensities toward retaliatory aggression (see Bushman, 2002; see also Sections 2.2, 3.2).

It is at this point that effortful control processes become relevant. High-trait-anger individuals are unlikely to intervene to control more automatic processes responsible for increasing anger. As such, these individuals are more vulnerable to their early-operating cognitive biases. However, low-trait-anger individuals have learned to control such automatic tendencies, and they do so by recruiting effortful control resources (see Sections 2.4, 3.3).

Effortful control has long been seen as exerting its influence on emotional outcomes by overriding more automatic cognitive tendencies (Eisenberg et al., 2004; Posner & Rothbart, 2000). Within the current model, there are three fashions in which effortful control could exert such an influence. First, effortful control resources could be used to *reappraise* the situation, such that early hostile interpretations are replaced by interpretations of a less hostile nature (Anderson & Bushman, 2002; Ochsner & Gross, 2004). Second, effortful control resources could be used to *distract* oneself from unwanted rumination on hostile information (Mischel & Ayduk, 2004; Posner & Rothbart, 2000). Third, effortful control resources could be used to *suppress* outward manifestations of anger, including aggressive behavior and nonverbal manifestations of anger (e.g., facial expressions) (DeWall et al., 2007; Gross, 1998). Because extant research has rarely focused on the specific pathways by which effortful control reduces anger, testing these proposals will be an important goal for future research.

Thus, our model posits that high-trait-anger individuals are more prone to the hostile interpretation bias and that this triggers further automatic processes related to ruminative attention and the amplification of anger and aggressive impulses. However, we also posit that low-trait-anger individuals are more likely to control hostile thoughts when they arise and have learned to do so spontaneously. In our view, then, high-trait-anger individuals are angry both because they are more prone toward hostile interpretations *and* because they engage in fewer cognitive processes important in self-regulating their hostile thoughts.

4. BROADER CONSIDERATIONS

The central goal of this review was to use social-cognitive models as a starting point for examining the cognitive processing basis of trait anger and reactive aggression. Related to this goal, we have reviewed a large set of findings and have offered a model that attempts to integrate the strengths of prior theory and data. Hence, our review is more comprehensive concerning the cognitive processing substrates of trait anger than any previous review. This said, trait anger can clearly be viewed from perspectives other than a cognitive one. In this vein, temperamental, developmental and social interaction perspectives are important to consider. The final major section of this review presents a broader discussion of these perspectives on trait anger. In general terms, we view the cognitive approach and alternative approaches as complementary rather than antagonistic, and we use this final section to begin building bridges across cognitive, biological, and social interactionist levels of analysis.

4.1. Biologically Based Temperament

Historically, social-cognitive theories of personality (e.g., Cervone & Shoda, 1999; Mischel & Shoda, 1995) have been presented as a challenge to the traditional view that personality reflects biologically based differences in temperament that are invariant across situations (e.g., Costa & McCrae, 1997; Funder, 1991). Indeed, social-cognitive theorists are quite adamant that personality operates in a situation-specific manner (Cervone & Shoda, 1999; Mischel & Shoda, 1995). And although there have been some recent suggestions that temperament-based and social-cognitive views of personality might conceivably be reconciled (e.g., Mischel, 1999), it is also true that the social-cognitive perspective tends to de-emphasize biological factors and in fact has not inspired many biologically relevant investigations. Furthermore, one can highlight some cases in which social-cognitive

perspectives on anger and reactive aggression are very critical of temperament-based approaches (e.g., Zelli & Dodge, 1999).

Based on this intellectual history, one might assume that our emphasis on cognitive process is meant as a challenge to biological views of trait anger that emphasize its genetic foundation. This implication is *not* intended in the present analysis. Rather, we take it as a proven fact that genetic factors clearly contribute to trait anger. In support of this point, we note that behavioral genetic studies have consistently implicated the importance of heritability factors in understanding individual differences in trait anger (e.g., Goldsmith, Buss, & Lemery, 1997) and reactive aggression (Brendgen, Vitaro, Boiven, Dionne, & Pérusse, 2006). A complete theory of trait anger should therefore at least address the biological basis of this trait.

In this connection, we join a growing chorus of researchers who suggest that it is time to develop more sophisticated process models to understand the biological bases of personality (Canli, 2006; Dodge & Pettit, 2003; Hariri & Weinberger, 2003). Molecular geneticists have long recognized that the causal relationship linking gene variants to personality traits must necessarily travel a long chain of events, including cellular processes, neurotransmitter functions, and the operations of particular neurological systems (e.g., Plomin & Caspi, 1999). Moreover, it is becoming increasingly apparent that the functions of many of the neurological systems involved in this causal chain centrally implicate individual differences in cognitive processing (Canli, 2006; Hariri & Weinberger, 2003). Although establishing such links between genetic variations, neurocognitive functions, and personality is difficult and results are preliminary at the present time, we do suggest that such processing frameworks point to the compatibility of the biological and cognitive approaches to personality.

To illustrate this point, it is useful to highlight developments related to the individual differences in the 5-HTTLPR serotonin-transporter gene. Initially, it was suggested that variations in this gene might provide a biological basis for understanding the broad trait of neuroticism (Greenberg et al., 2000; Jang et al., 2001; Lesch et al., 1996). However, such results have been difficult to replicate (Munafò, Clark, & Flint, 2005; Schinka, Busch, & Robichaux-Keene, 2004). Such difficulties have led to the suggestion that it may be more productive to link 5-HTTLPR polymorphisms to neurocognitive processes, which are viewed as more proximal to the functioning of this gene (Canli, 2006; Hariri & Weinberger, 2003).

Indeed, this process-based approach has been more successful than an approach based on linking specific gene variants to self-reported traits. For example, Hariri and Forbes (2007) found a strong and replicable relationship between 5-HTTLPR polymorphisms and the amygdala's response to negative emotional stimuli. Further considerations indicated that this link is due to the deficient top-down control of the amygdala by regions of the ACC (Pezawas et al., 2005). In other words, short allele carriers of this gene appear to exhibit deficient effortful control abilities, particularly when challenged by negative affect (Hariri & Forbes, 2007). We suggest that these recent developments illustrate the compatibility of biological and cognitive approaches to personality, with full recognition that a great deal of additional work along these lines is needed (Canli, 2006).

4.2. Developmental Influences

Although the previous section encourages a focus on genetic factors, it is nonetheless true that behavioral genetic studies also highlight a clear environmental influence on trait anger and reactive aggression (Brendgen et al., 2006; Goldsmith et al., 1997). Thus, investigating the early environmental antecedents of trait anger and reactive aggression is an important research direction as well. In this connection, developmental researchers have suggested that social-cognitive processes are likely to mediate links between early socialization influences and later tendencies toward anger and aggression (e.g., Dodge, Bates, & Pettit, 1990). Although a full treatment of this developmental literature is beyond the scope of this review (for a more thorough treatment, see Dodge & Pettit, 2003), it is useful to briefly highlight the manner in which cognitive processes are likely to mediate developmental influences on anger and reactive aggression.

Early physical abuse has long been known to be a risk factor for later aggression (Malinosky-Rummel & Hansen, 1993), and further evidence suggests that such influences are specific to reactive forms of aggression (e.g., Cornell, Benedek, & Benedek, 1987; Dodge, Lochman, Harnish, Bates, & Pettit, 1997). Given the obvious risk of physical harm associated with abuse, it is not that surprising that abused children develop hostile interpretation biases (Dodge, Bates, et al., 1990; Dodge, Pettit, Bates, & Valente, 1995) along with difficulties disengaging attention from hostile stimuli in the environment (Pollak & Tolley-Schell, 2003). After all, such biases would alert abused children to the possibility of imminent bodily harm. It is perhaps ironic, then, that these seemingly sensible cognitive adaptations actually appear to predispose abused children to become perpetrators of violence themselves later in life (Dodge, Bates, et al., 1990; Dodge et al., 1995).

On a more positive note, it has been suggested that parents have the opportunity to teach their children effective effortful control skills by responding appropriately to their child's distress (e.g., Gottman, Katz, & Hooven, 1997).

Parents who maintain a warm interpersonal style and calmly coach their child through distressing circumstances have been shown to foster effortful control abilities within their child, and these abilities are useful in ameliorating later tendencies towards anger and aggression (Carlson & Parke, 1996; Eisenberg et al., 1999; Gottman et al., 1997). By contrast, parents who respond to a child's distress by minimizing the distress or by punishing the child will fail to cultivate their child's effortful control skills, rendering them more vulnerable to their angry and aggressive tendencies in the future (e.g., Eisenberg et al., 1999).

Our presentation of such developmental data is necessarily brief given the other goals of this review. However, it is apparent that early socialization plays a significant role in the development of social-cognitive tendencies, including the cognitive tendencies highlighted in the present review. It is comforting to us that the identified processing biases do not operate in a vacuum but are instead deeply embedded in the developmental context of nature and nurture.

4.3. Shaping the Environment

Our review has emphasized the role of cognitive processes in the determination of an individual's reactivity to hostile situations. However, it is also true that a person's personality plays an important role in shaping her or his social environment (Anderson & Carnagey, 2004; Crick & Dodge, 1994; T. W. Smith et al., 2004). Consider the violence escalation cycle that has been eloquently described by many past authors (e.g., Anderson & Carnagey, 2004; Zillmann, 1993). This cycle begins with one person engaging in a minor transgression toward another (e.g., a rude comment). The second person becomes irritated by this transgression and responds with what he or she perceives to be an equivalent retaliation. The first person, however, does not see this retaliation as equivalent, but rather views it as an unwarranted escalation (e.g., Stillwell & Baumeister, 1997). As such, this person becomes angry and responds in a more hostile manner. This cycle continues to escalate until irritation has become rage and minor quips have become yells, screams, and even acts of physical violence.

From this description, then, it becomes clear how individuals high in trait anger can actively create their own hostile environment by provoking hostility from others. There are several sources of data consistent with this idea. Dodge, Price, Coie, and Christopoulos (1990) found that reactive aggression was typically operative in mutually aggressive dyads of children and that reactive aggression seldom remained one-sided. In the adult literature, Baron et al. (2007) found that wives high in trait anger were more likely to evoke arguments and conflict from their husbands and that these conflicts, in turn, predicted subsequent decreases in the quality of marital relations. Related conclusions have also been made in laboratory studies of personality and dyadic interaction (e.g., Graziano et al., 1996). In short, there is little doubt that high-trait-anger individuals often evoke hostile responses from others.

We view this perspective as highly compatible with a focus on cognitive process. Because cognitive processes are involved in determining one's response to the environment, it is likely that these processes are instrumental in evoking hostility from others. Consistent with this view, Hubbard, Dodge, Cillessen, Coie, and Schwartz (2001) found that the hostile interpretation bias was an important predictor of dyadic levels of reactive aggression. Future research should begin to extend this view by entertaining the possibility that ruminative attention processes are involved in amplifying this escalation cycle (see Bushman, Bonacci, Pedersen, Vasquez, & Miller, 2005) and that effortful control tendencies might be useful in defusing it (see Vohs & Ciarocco, 2004). In general terms, though, we view it as likely that the cognitive biases linked to trait anger are also linked to evoking hostility from others.

CONCLUSION

Several prior social-cognitive theories have highlighted the potential cognitive operations associated with anger and reactive aggression. Our review sought to extensively review such material in favor of an empirically informed and integrated model. We concluded that processes related to automatic hostile interpretations, ruminative attention, and effortful control are robust predictors of trait anger. It is our hope that the integrative cognitive framework presented here will guide future investigations related to the cognitive basis of trait anger.

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