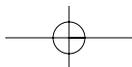
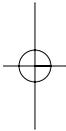
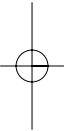


## II

# NATURAL AND THERAPEUTIC FUNCTIONS OF ANGER AND ITS EXPRESSION



## 4

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*Anger: Causes and Components*

Eddie Harmon-Jones &amp; Cindy Harmon-Jones

Emotions can be considered processes that involve involuntary action readiness (Frijda, 1986). Basic emotions, such as anger, provide organisms with relatively complex and biologically prepared behavioral potentials that assist in coping with major challenges to their welfare (Panksepp, 1998). However, these inherited behavioral potentials only suggest ways of behaving as organisms evolved to have larger, more complex brains. Thus, although humans may possess the same emotional instincts as other animals, we may not be as controlled by the dictates of emotions and thus we have more choices (Panksepp, 1994). Consequently, our emotions can be regulated and thus may not directly affect behavior.

An emotion is not a “thing” but is best considered a process that is made up of basic processes such as feelings of pleasure or displeasure, facial-expression components, particular appraisals, and particular action plans and activation states (Frijda, 1993). Anger is a relatively unpleasant feeling, and it is described using words like *annoyed*, *angry*, and *enraged*, which in our view, express differences in intensity (cf. Lewis, 1993, however, who suggested that rage and anger are qualitatively different). When left uncontrolled or uninhibited, its facial expression involves the muscles of the brow moving inward and downward, thus “creating a frown and a foreboding appearance around the eyes, which seem to be fixed in a hard stare toward the object of anger. The nostrils dilate and the wings of the nose flare out. The lips are opened and drawn back in a rectangle-like shape, revealing clinched teeth. Often the face flushes red” (Izard, 1977, p. 330). Because humans are taught to control anger and its expression, the expressions of anger vary considerably from one person to another, but “on the face of an angry person there is almost always one or more of the innate components of the natural expression which signals his or her internal state” (Izard, 1977, p. 330).

In this chapter, we review recent research and theoretical advances in the study of basic processes involved in anger. Anger has been suggested to serve a variety of adaptive functions. It organizes and regulates several psychological processes, such as self-defense and mastery. It also regulates social and interpersonal behaviors, and organizes behaviors to assist with goal-directed action. However, because anger may give rise to maladaptive cognitions and behaviors, individuals and societies often attempt to regulate anger as a way of preventing intra- and interpersonal negative consequences, such as aggression.

We focus our review on the causes of anger, its subjective feeling and motivational components, and some of its neural components. In doing so, we consider all of the component processes typically involved in anger — its feelings, appraisals (under causes), action plans and activation states (under motivation), and physiology. However, we do not review the literature on angry facial expressions, as it is beyond the scope of this chapter (for a recent review, see Russell & Fernández-Dols, 1997).

### SUBJECTIVE FEELINGS AND ANGER

The conception of anger advanced in this chapter is much broader than some others, which suggest that there are different kinds of anger. For example, Ellsworth and Scherer (2003, p. 575) wrote, "Rather than a single emotion of anger, there can be many varieties of 'almost anger' and many nuances of the anger experience."

We do not reject such a possibility, but instead suggest a broader view that proposes that there is an important commonality overriding the "nuances" of anger experience. Spielberger et al. (Spielberger, Jacobs, Russell, & Crane, 1983; Spielberger, Reheiser, & Sydeman, 1995) reflected this notion in regarding *anger* as encompassing low-intensity feelings such as irritation or annoyance as well as high-intensity feelings such as fury and rage. A factor analysis of the items in his State Anger scale (such as "I am furious" and "I feel irritated") obtained only a single factor, suggesting that the feelings tapped by these items reflected a unitary affective state varying in intensity. Spielberger's (Spielberger et al., 1983, 1995) distinction between "anger-in" and "anger-out," it should be noted, refers to differences in the *predisposition (i.e., trait) to openly express* the motoric concomitants of anger rather than qualitative differences in the nature of the angry feelings (Spielberger et al., 1995). Our conception of anger experience is in accord with the prototype view of emotion concepts advanced by Shaver, Schwartz, Kirson, and O'Connor (1987). Shaver et al. found that the anger prototype indicates that a variety of feelings labeled *irritation, annoyance, exasperation, disgust, and hate* are often included within the

## 4. ANGER DYSREGULATION

101

general notion of anger. In summary, there is some justification to not regarding the various “nuances” of anger experience as distinctly different emotional or affective states.

It is often held that emotions, unlike moods, are about something in particular; they have a more definite cause and/or a more specific target. However, this clarity and/or focus is a matter of degree, as Frijda (1986, pp. 59–60) recognized, and people can vary in the extent to which they believe they know what produced the mood they are experiencing. As Frijda put it, the distinction between mood and emotion is “unsharp” (p. 60). If people can vary in the extent to which they have a clear conception of the cause of their affective arousal, where do we place the cutting point on this continuum, putting mood on one side and emotion on the other?

**Valence**

Anger is often regarded as a negative emotion by laypersons as well as psychological scientists. However, what is meant by negative is not always clearly defined in the literature. Emotions can be regarded as positive or negative (a) *because of the conditions that evoked the emotion*; (b) *because of the emotion’s adaptive consequences*; or (c) *because of the emotion’s subjective feel*.

Thus, the emotion of anger can be viewed as negative when considering the conditions that evoked the emotion, because anger is evoked by aversive events. Anger could be viewed as either positive or negative when considering its adaptive consequences, depending on the outcome of the situation in which anger occurred. However, one would also need to define for whom the consequences are adaptive—the individual expressing the anger or the individual or group receiving it, and whether the consequences are adaptive in the short term or long term. Finally, anger could be viewed as either positive or negative when considering the subjective feel or evaluation of the emotion, depending on whether an individual likes or dislikes the subjective experience of anger.

In considering the valence of an emotion, the definition of emotion must also be considered. Although there is no completely accepted definition of emotion, some scientists focus on the stimulus conditions when defining an emotion (e.g., negative situation blamed on another causes anger), whereas other scientists focus on the responses evoked when defining an emotion (e.g., anger involves certain physiological changes, behavioral expressions, and subjective feelings). The stimulus-based definitions indicate that the individual’s evaluation of the stimulus causing the emotion determines the valence of the emotion (Lazarus, 1991). Thus, most appraisal theorists regard whether the emotion-evoking situation is appraised as positive or negative as the most important and frequent way

of distinguishing positive from negative emotions. By this definition, then, anger is a negative emotion.

Response-based definitions of emotion indicate that the individual's subjective evaluation of the feeling determines the valence of the emotion. When anger is examined as a subjective experience, however, it is not necessarily negative; it can be subjectively accepted or rejected. Anger can be evaluated positively by the person experiencing the emotion, as when an individual says, "I like how it feels when I am furious." Although many persons find the experience of anger unpleasant, some individuals may find it relatively more pleasant.

In general, both state and trait studies examining the valence of anger indicate that most individuals regard anger as a negative experience. However, there are some individuals who routinely find the experience of anger more positive or less negative than other individuals find anger (Harmon-Jones, 2004). Moreover, these individual differences in attitudes toward anger relate positively to Buss and Perry (1992) trait anger and trait hostility (as measured by the Positive and Negative Affect Schedule-Expanded [PANAS-X], of Watson & Clark, 1991), although the correlations are not so high as to suggest redundancy. These individual differences in attitude toward anger also relate negatively to trait fear (as measured by PANAS-X). Attitudes toward anger does not relate to self-reported affect intensity or social desirability. Thus, although the valence of anger is predominantly negative, some individuals find it less negative than others, and these attitudes toward anger may have important consequences.

### **Relationship to Other Emotional Experiences**

In a given situation, anger may be the primary or even sole emotional experience. However, often times, anger occurs amid other negative emotions, as many conceptual perspectives recognize (e.g., Berkowitz, 1989). For example, in a recent experiment, anger was manipulated using an interpersonal insult and self-reported affect was measured following the insult (Harmon-Jones, Vaughn-Scott, Mohr, Sigelman, & Harmon-Jones, 2004). In addition to reporting feeling more anger, insult condition participants reported feeling more active, alert, determined, proud, and strong than the no-insult control condition participants. These latter items are from the PANAS measure of activated positive affect (Watson, Clark, & Tellegen, 1988). On the surface, these results suggest that the insult manipulation caused more activated positive affect. Such an interpretation would be consistent with the idea that the activated positive affect scale is measuring approach motivation (Watson, 2000). However, another interpretation is that the words did not reflect feelings of positivity in this situation in which anger was present.

## 4. ANGER: CAUSES AND COMPONENTS

103

These results for activated positive affect have since been replicated using a different anger manipulation. In addition, trait behavioral activation system (BAS; Gray, 1987) sensitivity was positively related to both reported anger and reported activated positive affect, providing convergent evidence. Moreover, anger and activated positive affect were positively correlated (Harmon-Jones, Harmon-Jones et al., 2005).

### MOTIVATIONAL COMPONENTS OF ANGER

A number of theorists have suggested that anger is an emotion that evokes behavioral tendencies of approach (e.g., Darwin, 1872/1965; Ekman & Friesen, 1975; Plutchik, 1980; Young, 1943). Of course, emotions are complex phenomena and discrete emotions may elicit both approach and withdrawal tendencies. However, we believe that the dominant behavioral tendency associated with anger is approach.

#### Behavioral and Subjective Evidence

Indeed, research has indicated that anger is often associated with attack (e.g., Berkowitz, 1993). Moreover, Depue and Iacono (1989) have suggested that irritable aggression is part of the behavioral facilitation system, a biobehavioral system similar to the BAS (Gray, 1987), which has been found to be associated with relative left prefrontal cortical activity (Harmon-Jones & Allen, 1997; Sutton & Davidson, 1997), a cortical region thought to be involved in approach motivation. Whether anger results in a general tendency to approach as compared to a specific tendency to aggress is currently a topic of debate with some suggesting the former (Lewis, 1993) and some the latter (Berkowitz, 1999).

In support of the idea of anger evoking approach motivation, Lewis, Alessandri, and Sullivan (1990; Lewis, Sullivan, Ramsey, & Alessandri, 1992), in studies on contingency learning, found that infants who displayed anger during extinction demonstrated the highest levels of joy, interest, and a required arm pull operant when the learning portion of the task was reinstated. Thus, subsequent to frustrating events, anger may maintain and increase task engagement and approach motivation.

In other research with adult humans, Baron (1977) demonstrated that angry individuals are reinforced positively by signs of their tormentor's pain. The participants who had been deliberately provoked by another individual had an opportunity to assault him in return. Indications that their first attacks were hurting their target led to increased aggression for previously provoked participants, but to reduced aggression for unprovoked participants. The initial signs of their victim's suffering showed the

angry persons they were approaching their aggressive goal and thus evoked even stronger assaults from them. Other research is consistent with these findings (e.g., Berkowitz, Cochran, & Embree, 1981).

Additional support for the idea that anger is associated with approach motivation comes from research testing the conceptual model that integrated reactance theory with learned helplessness theory (Wortman & Brehm, 1975). According to this model, how individuals respond to uncontrollable outcomes depends on their expectation of being able to control the outcome and the importance of the outcome. When an individual expects to be able to control outcomes that are important, and those outcomes are found to be uncontrollable, psychological reactance should be aroused. Thus, for individuals who initially expect control, the first few bouts of uncontrollable outcomes should arouse reactance, a motivational state aimed at restoring control. After several exposures to uncontrollable outcomes, these individuals should become convinced that they cannot control the outcomes and should show decreased motivation (i.e., learned helplessness). In other words, reactance will precede helplessness for individuals who initially expect control. In one study testing this model, individuals who exhibited angry feelings in response to one unsolvable problem had better performance and were presumably more approach motivated on a subsequent cognitive task than did participants who exhibited less anger (Mikulincer, 1988).

Other research has revealed that state anger relates to high levels of self-assurance, physical strength, and bravery (Izard, 1991), inclinations associated with approach motivation. Additionally, Lerner and Keltner (2001) found that anger (both trait and state) is associated with optimistic expectations, whereas fear is associated with pessimistic expectations. Moreover, happiness was associated with optimism, making anger and happiness appear more similar to each other in their relationship with optimism than fear and anger. Although Lerner and Keltner interpreted their findings as being due to the appraisals associated with anger, it seems equally plausible that it was the approach motivational character of anger that caused the relationship of anger and optimism. That is, anger creates optimism because anger engages the approach motivational system and produces greater optimistic expectations.

Other evidence supporting the idea that anger is associated with an approach orientation comes from research on bipolar disorder. The emotions of euphoria and anger often occur during manic episodes of bipolar disorder (Cassidy, Forest, Murry, & Carroll, 1998; Depue & Iacono, 1989; Tyrer & Shopsin, 1982). Both euphoria and anger may be approach-oriented processes, and a dysregulated or hyperactive approach system may underlie mania (Depue & Iacono, 1989; Fowles, 1993). Research suggests that hypomania/mania involves increased left frontal brain activity and

## 4. ANGER: CAUSES AND COMPONENTS

105

approach motivational tendencies. In this research, it has been found that individuals who have suffered damage to the right frontal cortex are more likely to evidence mania (see review by Robinson & Downhill, 1995). Thus, this research is consistent with the view that mania may be associated with increased left frontal activity and increased approach tendencies, because the approach motivation functions of the left frontal cortex are released and not restrained by the withdrawal system in the right frontal cortex. Furthermore, lithium carbonate, a treatment for bipolar disorder, reduces aggression (Malone, Delaney, Luebbert, Cater, & Campbell, 2000), suggesting that anger and aggression correlate with the other symptoms of bipolar disorder. In addition, trait anger has been found to relate to high levels of assertiveness and competitiveness (Buss & Perry, 1992).

Recently, two additional individual-differences studies were conducted to test the hypothesis that trait anger is related to trait approach motivation, or more specifically, to trait BAS sensitivity (Harmon-Jones, 2003). In both studies, trait BAS sensitivity, as assessed by Carver and White's (1994) scale, was positively related to trait anger, as assessed by the Buss and Perry (1992) aggression questionnaire. One of the two studies found that trait anger also related to trait behavioral inhibition system (BIS) sensitivity. In both studies, general negative affect was statistically controlled. This was done because anger's association with general negative affect (Berkowitz, 1999, 2000; Watson, 2000) may cause the association of BIS and anger. That is, the affect of anger has two subcomponents: a nonspecific component that reflects the contribution of general negative affect (Berkowitz, 1999; Watson, 2000) and a more specific component that reflects the unique qualities of anger (Watson, 2000). In other words, at the simple correlation level, anger may be associated with BIS, but when controlling for negative affect, anger will not be associated with BIS but will only be associated with BAS. Results supported this prediction in both studies. Additional results in Study 2 revealed that BAS was positively correlated with physical aggression, and simultaneously regressing aggression onto BAS, BIS, and general negative affect revealed that physical aggression was positively related to BAS, negatively related to BIS, and positively related to negative affect. Carver (2004) has also found that trait BAS predicts state anger in response to situational anger manipulations. These results support the hypothesis that anger is related to approach motivation.

### CAUSES OF ANGER

Researchers have often considered anger to be the result of physical or psychological restraint or of interference with goal-directed activity (Darwin,

1872/1965; Izard, 1977; Lewis, 1993). This action-oriented approach to understanding the cause of anger is consistent with postulations advanced by other major theoretical perspectives.

### Reinforcement Approaches

For example, neo-behaviorists suggested that the actual or signaled arrival or termination of pleasant or unpleasant events (positive or negative reinforcers) was the primary cause of emotions (Mowrer, 1960). Gray (1987) extended these ideas by including stimulus omissions and interactions with individuals' resources, such as ability to deal with events (see also Rolls, 1999). According to these models, angry emotions (like frustration, anger, and rage) occur as a result of the omission of a positive reinforcer or the termination of a positive reinforcer. Along these lines, Lewis (1993) proposed that the thwarting of a goal-directed action is an unlearned cause of anger. In one experiment, after 2- to 8-month-old infants were conditioned to move one of their arms in order to see a picture of another baby's smiling face, the infants were exposed to an extinction phase in which the arm movement no longer revealed the happy picture. This "frustrating" event caused the majority of the infants to exhibit angerlike facial expressions (Lewis et al., 1990).

Similarly, in considering the causes of anger, Berkowitz (1989) extended the original frustration-aggression model (Dollard, Doob, Miller, Mowrer, & Sears, 1939) with a cognitive neo-associative model of anger and aggression. According to this model, any unpleasant situation, including pain, discomfort, frustration, or social stress, provokes negative affect. This negative affect is associated with fight-and-flight motivation. The individual's prior experiences have formed associations that provide cues relating to the present situation. If these cues lead him or her to desire primarily to escape, then the flight system is activated and the person experiences mostly fear. If the cues lead him or her to desire to attack, then the fight system is activated and he or she experiences mostly anger.

### Cognitive Appraisal Approaches

The other main theoretical approach aimed at understanding the causes of anger is the cognitive approach. Much of the recent theorizing on causes of anger has come out of this literature. These theorists propose that emotions are caused by an individual's appraisal of a situation. According to appraisal theorists, persons constantly evaluate (appraise) the situations in which they find themselves. A central assumption of appraisal theories is that it is not the situation itself that causes emotion, but rather the ways in which the individual appraises the situation (e.g., Roseman, Spindel, & Jose, 1990).

## 4. ANGER: CAUSES AND COMPONENTS

107

All appraisal theorists agree that anger is evoked in negatively appraised situations. These situations are often described as situations where the individual's goals are blocked. To clarify what is meant by "goals," some theorists state that the instigating circumstance must be evaluated as personally significant in some way, so that it has goal relevance, if there is to be an angry reaction (Lazarus, 1991; Scherer, 2001). Goals are defined very broadly by some researchers, including not only consciously sought goals, but also basic needs. Thus, pain or discomfort could be considered as blocking the individual's goal to be comfortable. Roseman (1991) defined an anger-evoking situation as one appraised as delivering the absence of a reward or the presence of punishment, whereas Lazarus and Scherer defined an anger-evoking situation as one appraised as containing an obstruction to goal attainment.

Negatively appraised situations are associated with all of the emotions considered to be negative, including fear, sadness, and anger. Theorists have sought the necessary conditions required in order to cause anger, rather than a different negative emotion, to be evoked. One condition that has been proposed as necessary for anger to occur is an appraisal of "other-blame," that is, an assessment by the individual that someone or something has wrongly caused the negative situation to occur (Lazarus, 1991; Ortony, Clore, & Collins, 1988). Some appraisal theorists have proposed that anger occurs only when the individual appraises the evoking event as wrong, unfair, or improper (Kuipers, & ter Schure, 1989; Roseman, 1991; Shaver et al., 1987, Frijda). Lazarus proposed that, in order for anger to occur, the individual must perceive a threat against self-esteem.

Another characteristic that appraisal theorists have proposed as necessary for anger is an appraisal of *high coping potential* in the negative situation. By this, they mean that individuals become angry when they believe that they have a high likelihood of being able to rectify the negative situation and to prevent the undesired consequences (Lazarus, 1991; Scherer, 2001; Stein & Levine, 1989). In negative situations where the individual appraises low coping potential, by contrast, these theorists propose that sadness, fear, or anxiety is experienced instead of anger.

### Problems With the Appraisal Accounts

Appraisal theorizing has attracted much interest in recent years and has dominated recent thinking about the causes of emotions in general. On one hand, the idea that anger results from an appraisal that the situation is (a) negative, (b) threatens self-esteem, (c) is caused by others, and (d) is one that we expect to be able to rectify has intuitive appeal. That is, many of us can easily recall instances where we experienced anger and it seemed that the anger resulted from such appraisals. However, our intuitions may be wrong.

Indeed, the appraisal literature has been criticized for failing to provide evidence as to whether appraisals cause emotion or whether emotion motivates the individual to make appraisals. Frijda (1993; Frijda & Zeelenberg, 2001) and Parkinson and Manstead (1992) have noted that, because of the verbal-report methods employed in most investigations in this area, it is unclear whether the identified appraisal characteristics preceded or followed the arousal of the emotional experience. "Nothing in the data resists the interpretation that the relevant appraisals were consequences rather than precedents of the emotional reactions" (Parkinson & Manstead, 1992, p. 129).

Other scientists have questioned the necessity of specific appraisals for anger (Berkowitz & Harmon-Jones, 2004a, 2004b). For example, Berkowitz and Harmon-Jones have argued that once the fight system and anger are activated, the person begins to make appraisals and to do other cognitive processing of the situation, in order to determine who or what to attack, and how or whether to follow through behaviorally with these impulses. This conception differs from the appraisal models in that it proposes that an appraisal of the provoking situation is not necessary in order to produce emotion. They do believe that appraisals are involved in the experience of anger, but see these as coming later in the process, and occurring with anger, or being provoked by anger, rather than being the cause of anger. They propose that Berkowitz's cognitive neo-associative model better accounts for all of the data, including atypical anger occurrences that do not fit well into models that assume the necessity of self-relevance, goals, and blameworthy behavior by another person. They also take issue with appraisal theorists' definitions of "goals," "cognitions," and "appraisals" that are sometimes so overly broad that they are untestable (e.g., the "goal" of not experiencing discomfort).

Regarding the necessity of the appraisal of other-blame for anger, it has been suggested that, although other-blame does often occur along with anger, it is the emotion of anger that motivates the individual to seek someone or something to blame for the negative situation. Frijda (1993) reports a number of instances where angry persons blamed, and even aggressed against, inanimate objects in a way that many would characterize as irrational, lending support to the idea that blaming is motivated by anger rather than the other way around.

Lazarus's (1991) claim that self-esteem threats are necessary for anger elicitation has also been questioned. Whereas self-esteem threats may be common in anger-evoking situations, studies have shown that persons sometimes report experiencing anger in response to frustration of transient goals that would not be expected to have high personal relevance. Moreover, it is not likely that the 2-month-old infants in Lewis and colleagues' experiments (1990) were concerned about self-esteem (though Lazarus would contend that such evidence should not be considered).

## 4. ANGER: CAUSES AND COMPONENTS

109

Finally, the claim that high coping potential is necessary for the experience of anger has recently been challenged by an experiment in which coping potential was manipulated and found to affect cortical activation (see later) but not the subjective experience of anger (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003).

### NEURAL COMPONENTS OF ANGER

Much recent research has examined the relation between anger and asymmetrical frontal cortical activity because past research had suggested that left frontal cortical activity was associated with approach motivation, whereas right frontal cortical activity was associated with withdrawal motivation. In one of the first studies along these lines, Harmon-Jones and Allen (1998) found that trait anger related to increased left frontal activity and decreased right frontal activity. More recently, Harmon-Jones (2004) addressed an alternative explanation for these results. The alternative explanation suggested that persons with high levels of trait anger might experience anger as a positive emotion, and this positive feeling or attitude toward anger could be responsible for anger being associated with relative left frontal activity. After developing a valid and reliable assessment of attitude toward anger, a study was conducted to assess whether resting baseline asymmetrical activity related to trait anger and attitude toward anger. Results indicated that anger related to relative left frontal activity and not attitude toward anger. Moreover, further analyses revealed that the relationship between trait anger and left frontal activity was not due to anger being associated with a positive attitude toward anger.

To address the limitations of the aforementioned correlational studies, experiments have been conducted in which anger is manipulated and its effects on regional brain activity are examined. In Harmon-Jones and Sigelman (2001), participants were randomly assigned to a condition in which another person insulted them or to a condition in which another person treated them in a neutral manner. Immediately following the treatment, EEG (electro/encephalogram) data were collected. As predicted, individuals who were insulted evidenced greater relative left frontal activity than individuals who were not insulted. Additional analyses revealed that within the insult condition, reported anger and aggression were positively correlated with relative left frontal activity. Neither of these correlations was significant in the no-insult condition. These results suggest that relative left frontal activation was associated with more anger and aggression in the condition in which anger was evoked. This research thus provides the first demonstration of a relationship between state anger and relative left frontal activation.

Recent experimental evidence has replicated these results and also revealed that state anger evokes both increased left and decreased right frontal activity. Moreover, a manipulation of sympathy for the person who would later insult the participant revealed that sympathy reduced the effects of insult on left and right frontal activity (Harmon-Jones et al., 2004). This research suggests that experiencing sympathy for another individual may reduce aggression toward that individual (e.g., see review by Miller & Eisenberg, 1988) by reducing the relative left frontal activity associated with anger.

In the two experiments just described, the designs were tailored in such a way as to evoke anger that was approach oriented. Although most instances of anger involve approach inclinations, as discussed earlier, not all instances of anger are associated with approach motivation. To manipulate approach motivation independently of anger, Harmon-Jones et al. (2003) performed an experiment in which the ability to cope with the anger-producing event was manipulated. Based on past research that has revealed that coping potential affects motivational intensity (Brehm & Self, 1996), it was predicted that the expectation of being able to take action to resolve the anger-producing event would increase approach motivational intensity relative to expecting to be unable to take action.

In the experiment, two conditions were run and they differed with regard to whether it was possible for participants to act to change the event that caused the anger, to manipulate coping potential or the expectation of acting to change the situation. Both conditions evoked significant increases in anger (over baseline) and they were not significantly different from each other. More important and consistent with predictions, results indicated that participants who expected to engage in the approach-related action evidenced greater left frontal activity than participants who expected to be unable to engage in approach-related action. Moreover, within the action-possible condition, participants who evidenced greater left frontal activity in response to the angering event also evidenced greater self-reported anger, providing support for the idea that anger is often an approach-related emotional response. In the condition where action was not possible, greater left frontal activity did not relate to greater anger. In our view, this is because, although anger usually leads to approach motivation, when action is not possible, approach motivation remains low, even if angry feelings are high. Finally, within the action-possible condition, participants who evidenced greater left frontal activity in response to the event were more likely to engage in behaviors that would reduce the possibility of the angering event from occurring in the future (i.e., they were more likely to sign the petition and to take petitions with them for others to sign to prevent a possible tuition increase at their university). This finding suggests that greater approach motivation, as reflected in greater left frontal cortical activity, was associated with more action to correct the negative situation.

## 4. ANGER: CAUSES AND COMPONENTS

111

This research suggests that the left frontal region is most accurately described as a region sensitive to approach motivational intensity. It was only when anger was associated with an opportunity to behave in a manner to resolve the anger-producing event that participants evidenced the increased relative left frontal activation. The effect of increased left frontal cortical activation being evoked during instances of anger where approach-related action is possible has been replicated (Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006). The results of these two experiments should not be taken to indicate that such explicit manipulations of action possibility are always necessary. Manipulations of action possibility may only potentiate the effects of emotion manipulations on asymmetrical frontal cortical activity. Indeed, in a recent study, participants were exposed to anger-inducing pictures (and other pictures) and given no explicit manipulations of action expectancy. Across all participants, a null effect of relative left frontal asymmetry occurred. However, individual differences in trait anger related to relative left frontal activity to the anger-inducing pictures, such that individuals high in trait anger showed greater left frontal activity to anger-producing pictures (controlling for activity to neutral pictures; Harmon-Jones, 2005).

Other research is consistent with the hypothesis that anger is associated with left frontal activity. For example, d'Alfonso, van Honk, Hermans, Postma, and de Haan (2000) recently used slow repetitive transcranial magnetic stimulation (rTMS) to inhibit the left or right prefrontal cortex. Slow rTMS reduces cortical excitability, so that rTMS applied to the right prefrontal cortex decreases its activation and causes the left prefrontal cortex to become more active, whereas rTMS applied to the left prefrontal cortex causes activation of the right prefrontal cortex. They found that rTMS applied to the right prefrontal cortex caused selective attention toward angry faces whereas rTMS applied to the left prefrontal cortex caused selective attention away from angry faces. Thus, an increase in left prefrontal activity led participants to attentionally approach angry faces, as in an aggressive confrontation. In contrast, an increase in right prefrontal activity led participants to attentionally avoid angry faces, as in a fear-based avoidance. The interpretation of these results is supported by research demonstrating that attention toward angry faces is associated with high levels of self-reported anger and that attention away from angry faces is associated with high levels of cortisol (van Honk, Tuiten, de Haan, van den Hout, & Stam, 2001; van Honk et al., 1998, 1999).

### Research on Anger Using Other Brain-Imaging Methods

The reviewed research has revealed that the left frontal cortical region is involved in approach motivated anger. Few studies using brain-imaging

technologies other than EEG have been conducted.<sup>1</sup> In one, positron emission tomography (PET<sup>2</sup>; oxygen-15-labeled carbon dioxide) was measured while men were exposed to personally created angry or neutral mental imagery scripts. Results revealed that as compared to neutral imagery, anger imagery caused an increase in the left orbital frontal cortex, the right anterior cingulate cortex, the bilateral anterior temporal poles, left precentral gyrus, bilateral medial frontal cortex, and bilateral cerebellum. Thus, the increase in activity in the left orbital frontal cortex is consistent with the anger research results obtained using EEG. However, Dougherty et al. (1999) interpreted the increase in left orbital frontal cortical activity as corresponding "to inhibition of aggressive behavior in the face of anger" (p. 471). Whereas this interpretation is consistent with some speculations of the role of the left orbital frontal cortex in response inhibition (Mega, Cummings, Salloway, & Malloy, 1997), it is inconsistent with the EEG results showing that increased left frontal activity is associated with increased aggression and approach behavior (e.g., Harmon-Jones & Sigelman, 2001; Harmon-Jones et al., 2003). The interpretation that the left frontal cortical region is involved in the inhibition of anger and aggression is also inconsistent with lesion data suggesting that mania results from damage to the right frontal region (e.g., Robinson & Downhill, 1995) and results obtained when the left relative to right frontal cortex is activated and angry attentional processes are measured (e.g., d'Alfonso et al., 2000). However, EEG is likely assessing dorsolateral frontal cortical activity and not orbital frontal activity, and left orbital frontal activity may be involved in the inhibition of anger, whereas left dorsolateral frontal activity may be involved in approach motivations like anger.

Of course, it may be difficult to compare anger induced by imagery to anger induced by insulting feedback or goal blocking, as in the EEG experiments. In the imagery experiments, there was no report of a significant association between reported anger and regional brain activity. In the EEG experiments, self-reported anger has been found to correlate significantly with relative left frontal activity. Such correlations assist in determining whether the brain activation is related to emotional experience or some other nonemotional variable.

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<sup>1</sup>Whereas there have been several studies examining neural responses to photographs of angry faces, there have been only a very few studies examining neural activity associated with the experience or expression of anger. Because the former type of studies are likely assessing neural processes associated with the perception of emotional stimuli and not necessarily the experience or expression of emotion, these studies are not reviewed.

<sup>2</sup>Positron emission tomography (PET) is a powerful imaging technique that accurately scans the cellular function of the human body by detecting radiation from the emissions of positrons. Positrons are tiny particles that are present in a radioactive substance that is administered to the patient or participant.

## 4. ANGER: CAUSES AND COMPONENTS

113

**CONCLUSION**

Empirical and theoretical developments on the causes of anger were reviewed. Although cognitive appraisal models of anger have received much attention, reinforcement and neo-associative models have been supported as well. Indeed, as Berkowitz's neo-associative model would suggest, appraisals may not be necessary to cause anger and they may only intensify it. In addition, recent research and theory regarding the subjective feelings and motivational components of anger were reviewed. Much of it suggests that anger is a negative feeling state that is also associated with subjective feelings such as bravery, self-assurance, determination, and strength, terms that some emotion models would call positive. These recent results suggest that more research is needed to understand how the situational context affects the valence of subjective feeling states and how these states relate to behavioral and physiological measures of anger and aggression. Finally, much recent research and theory has suggested that anger is associated with approach motivation, and that anger associated with strong approach inclinations is associated with greater left frontal and lesser right frontal cortical activation. Future research is necessary to understand the states and traits that might cause anger to instead be associated with other motivational tendencies and patterns of brain activity. Given these recent advances in research and theory, a more complete understanding of anger is emerging. Such may assist in its regulation and control.

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115

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## 4. ANGER: CAUSES AND COMPONENTS

117

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