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State Anger and Prefrontal Brain Activity: Evidence That Insult-Related Relative Left-Prefrontal Activation Is Associated With Experienced Anger and Aggression

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Research has demonstrated that left-prefrontal cortical activity is associated with positive affect, or approach motivation, and that right-prefrontal cortical activity is associated with negative affect, or withdrawal motivation. In past research, emotional valence (positive–negative) has been confounded with motivational direction (approach–withdrawal), such that, for instance, the only emotions examined were both positive and approach related. Recent research has demonstrated that trait anger, a negative but approach-related emotion, is associated with increased left-prefrontal and decreased right-prefrontal activity, suggesting that prefrontal asymmetrical activity is associated with motivational direction and not emotional valence. The present experiment tested whether state-induced anger is associated with relative left-prefrontal activity and whether this prefrontal activity is also associated with aggression. Results supported these hypotheses.

Research has demonstrated that the prefrontal regions of the brain are asymmetrically involved in the expression and experience of emotion. That is, the left-prefrontal region has been implicated in positive affective or approach-related processes, and the right-prefrontal region has been implicated in negative affective or withdrawal-related processes (Davidson, 1995; Fox, 1991; Heller, 1990; Silberman & Weingartner, 1986). This research has proceeded along two lines—examinations of the relationships between trait affective styles and resting prefrontal cortical activity (trait research), and examinations of prefrontal activity during the experience of situationally induced emotions (state research). For instance, research investigating trait affective styles has demonstrated that depression is associated with decreased left-prefrontal activity (Allen, Iacono, Depue, & Arbisi, 1993; Henriques & Davidson, 1990, 1991; Jacobs & Snyder, 1996), that activated positive affect (e.g., enthusiasm) is associated with increased left-prefrontal activity (Tomarken, Davidson, Wheeler, & Doss, 1992), that activated negative affect (e.g., fear) is associated with increased right-prefrontal activity (Tomarken et al., 1992), and that behavioral activation sensitivity (BAS) is associated with increased left-prefrontal activity (Harmon-Jones & Allen, 1997; Sutton & Davidson, 1997). Research investigating state emotion has found that relatively greater left-prefrontal activity is associated with felt smiles (Ekman & Davidson, 1993) and positive facial expressions of emotion during joyful film clips (Davidson, Ekman, Saron, Senulis, & Friesen, 1990) and that relatively greater right-prefrontal activity is associated with negative facial expressions of emotion during disgusting film clips (Davidson et al., 1990).

Asymmetrical Prefrontal Activity: Emotional Valence or Motivational Direction?

Although research has demonstrated that the left- and right-prefrontal regions are involved in different emotional processes, the exact nature of this involvement is unclear. Some scientists have posited that asymmetrical prefrontal activity is due to the valence of the emotion, with left-prefrontal activity being associated with positive emotion and right-prefrontal activity being associated with negative emotion (Heller, 1990; Gotlib, Ranganath, & Rosenfeld, 1998; Nitschke, Heller, Palmieri, & Miller, 1999). Other scientists, however, have posited that asymmetrical prefrontal activity is due to the motivational direction of the emotion, with left-prefrontal activity being associated with approach motivation and right-prefrontal activity being associated with withdrawal motivation (Davidson, 1995; Fox, 1991; Harmon-Jones & Allen, 1997, 1998; Sutton & Davidson, 1997). Still other scientists have posited that relative left-prefrontal activity is associated with approach-related, positive emotions and that relative right-prefrontal activity is associated with withdrawal-related, negative emotions (Davidson, 1998).

Past research is unable to address whether prefrontal asymmetrical activity is associated with emotional valence or motivational direction, because the emotions that have been examined have

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confounded emotional valence and motivational direction. In other words, for the emotions examined, these two positions converge in their predictions of how different emotions relate to asymmetrical prefrontal activity, because the valence of the emotion and the direction of motivation are often directly related, such that positive emotions are approach related and negative emotions are withdrawal related. Anger, however, is an emotion that violates this relationship of valence and direction, because anger is considered a negatively valenced (Ekman & Davidson, 1994; Lazarus, 1991) but approach-related emotion (Darwin, 1872/1965; Ekman & Friesen, 1975; Levenson, 1994; Plutchik, 1980; Young, 1943). Indeed, recent research has found that trait anger relates to relatively greater left- than right-prefrontal brain activity during resting, baseline sessions (Harmon-Jones, 2000; Harmon-Jones & Allen, 1998). This trait research suggests that asymmetrical prefrontal activity reflects motivational direction rather than emotional valence.

Anger as Negatively Valenced

Most theorists consider anger a negative emotion (Ekman & Davidson, 1994; Ekman & Friesen, 1975; Lazarus, 1991). Many theorists classify emotions as positive or negative according to the eliciting situation. That is, anger is classified as a negative emotion because the situation is regarded as an unfavorable one. Situations that have been found to evoke anger are viewed as unfavorable or incongruent with one's goals (Lazarus, 1991).

However, emotions can also be regarded as positive or negative because of the evaluation of the feeling state. Anger would be classified as a negative emotion if individuals harbored a negative attitude toward the feeling of anger. Harmon-Jones (2000) recently demonstrated that, on the whole, the attitude toward anger is unfavorable. In addition, there are reliable and stable individual differences in attitudes toward anger, and some individuals have relatively more negative attitudes toward anger than do others. Moreover, attitudes toward anger relate to trait anger, with individuals scoring high in trait anger having more positive attitudes toward anger (Harmon-Jones, 2000). However, research has demonstrated that attitudes toward anger do not mediate the relationship between trait anger and resting asymmetrical prefrontal activity (Harmon-Jones, 2000). In other words, the positive valence of anger does not mediate the relationship between anger and relative left-prefrontal activity.

Anger as Approach Oriented

Theorists have suggested that anger is an emotion that evokes behavioral tendencies of approach (e.g., Darwin, 1872/1965; Ekman & Friesen, 1975; Levenson, 1994; Plutchik, 1980; Young, 1943). Consistent with this idea, research has indicated that anger is often associated with attack in the absence of a defensive motivation (e.g., Berkowitz, 1993). Moreover, anger has been described as part of the behavioral facilitation system (Depue & Iacono, 1989), a biobehavioral system similar to the BAS (Gray, 1972, 1987), which has been found to be associated with relative left-prefrontal activity (Harmon-Jones & Allen, 1997; Sutton & Davidson, 1997).[1]

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 phases of bipolar disorder. Both euphoria and anger may be approach-oriented processes, and a dysregulated or hyperactive approach system may underlie mania (Depue & Iacono, 1989; Fowles, 1993). Supporting this view, recent research has demonstrated that individuals with tendencies toward mania respond with increased left-prefrontal activity when confronted with an anger-producing event (Harmon-Jones, Abramson, Sigelman, Bohlig, & Hogan, 2001).

Additional support for the idea that anger is associated with approach comes from research that has tested the integrative model of reactance and learned helplessness (Wortman & Brehm, 1975). In this research, individuals who responded with anger to failure at one set of problems subsequently showed increased performance on a second, unrelated set of problems, whereas individuals who responded with depression subsequently showed decreased performance on the second set of problems (Mikulincer, 1988).

Similarly, studies on contingency learning have found that infants who displayed anger during extinction demonstrated the highest levels of a required arm pull operant when the learning portion of the task was reinstated. These studies also found that the infants who displayed anger during extinction expressed the most joy and interest when learning was reinstated (Lewis, Alessandri, & Sullivan, 1990; Lewis, Sullivan, Ramsey, & Alessandri, 1992). Finally, state anger has been found to relate to high levels of self-assurance, physical strength, and bravery (Izard, 1991), and trait anger has been found to relate to high levels of assertiveness and competitiveness (Buss & Perry, 1992). These diverse lines of research suggest that anger is associated with approach-related motivation.

Asymmetrical Prefrontal Activity and State Emotion

Although evidence suggests that anger is a negative and approach-oriented emotion and that trait anger is related to relative left-prefrontal activity, researchers do not know how state anger relates to asymmetrical prefrontal brain activity. Although models of the emotional functions of the prefrontal brain regions often assume that trait and state emotions relate in similar directions to asymmetrical prefrontal activity, very few experiments have tested these predictions. Indeed, given the remarkable stability of the prefrontal asymmetry (Tomarken, Davidson, Wheeler, & Kinney, 1992), there is reason to question the validity of this idea. Moreover, scientists consider state and trait emotion to reflect different processes (Russell & Feldman Barratt, 1999). Thus, the primary purpose of the present research is to test how asymmetrical prefrontal activity relates to state anger. On the basis of the preceding overview, we predicted that state anger would be associated with increased left-prefrontal activity.

[1] It is important to note that a motivation to approach does not always lead to approach behavior. Indeed, the expression "turn the other cheek" is an admonition to resist the approach motivation of anger. We believe that anger is often, but not necessarily, associated with approach motivational tendencies (for relevant evidence, see Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2001).

Relationship of Asymmetrical Prefrontal Activity With Aggression

Another purpose of the present research is to examine the relationship between anger-related asymmetrical prefrontal activity and aggression. Emotions such as anger can be conceived of as having motivational functions and as generating action tendencies (Brehm, 1999; Frijda, 1986). Of course, emotions may generate action tendencies that may not be manifest in overt behavior. However, on the basis of the aforementioned research, we propose that anger generates approach-related action tendencies that are generally aimed at resolving the anger-producing event. In the case of an insult, the action tendency may be aggression. Animal behavior researchers have posited that anger motivates offensive aggression, whereas fear motivates defensive aggression (e.g., Blanchard & Blanchard, 1984). If anger-induced relative left-prefrontal activity is involved in approach motivational processes, then greater anger-induced left-prefrontal activity may relate to increased aggression. Previous research on trait aggression and asymmetrical prefrontal activity has yielded tentative support for this prediction, in that relative left-prefrontal activity at baseline has been found to relate to greater self-reported trait aggression (Harmon-Jones, 2000; Harmon-Jones & Allen, 1998). To assess the relationship of relative left-prefrontal activity with aggression, we include in the present experiment a behavioral measure of aggression. We predicted that relative left-prefrontal activity in response to an anger-eliciting event would relate to increased aggression. In other words, because anger is conceived of as evoking an approach motivational tendency that should be represented in greater relative left-prefrontal activity, we predicted that the anger-related relative left-prefrontal activity would relate to behavioral manifestations of the motivation to approach and attack.

The Present Research

The present research was designed to assess whether relative left-prefrontal activity relates positively with state anger and aggression. On the basis of past research, we predicted that an anger induction would increase relative left-prefrontal activity and that individuals who responded to an anger induction with relatively greater left-prefrontal activity would show increased anger and aggression. To test these hypotheses, we designed an experiment in which participants were randomly assigned to conditions in which they were or were not insulted by another person. We recorded the electroencephalographic (EEG) activity immediately following the insult and then collected a behavioral measure of aggression and self-reported affect measures.

Method

Participants

Forty-two right-handed men who were undergraduates at the University of Wisconsin—Madison participated in exchange for extra credit in their introductory psychology course.[2] They were randomly assigned to condition.

Procedure

Participants were informed that the study concerned personality, psychophysiology, and perception. They were also told that another participant was in another room with another experimenter and that their study would be conducted in connection with this other participant's study. They were then told that there were two perception studies, the first involving person perception, and the second involving taste perception. After completing a baseline affect scale (see below), participants were prepared for an EEG recording, and then 8 min of resting, baseline EEG data were acquired.

After the baseline EEG recording, the experimenter explained the person perception study. Participants were told that they would be randomly assigned either to write an essay on a personally important social issue or to give their perception of the person who wrote such an essay. In fact, all participants were assigned to the role of writing the essay. They were given a choice of which topic to write about (i.e., the legality of smoking in public places, reducing the drinking age, or the use of animals in scientific research), and they were asked to write about the topic that was most important to them. After the participant finished his one-page essay arguing for the position, the experimenter collected the essay and ostensibly took it to the other participant for evaluation. The other participant did not actually exist.

After a few minutes, the experimenter returned and offhandedly mentioned that the participants could look at the evaluation of their essay. The evaluation was given to the participants in an envelope, so that the experimenter could remain unaware of condition. The evaluation was designed to be relatively neutral or relatively negative. The evaluation consisted of ratings ostensibly made by the other participant on the following 9-point bipolar scales: unintelligent–intelligent, thought-provoking–boring, friendly–unfriendly, illogical–logical, respectable–unrespectable, irrational–rational. The neutral evaluation consisted of ratings of 7 for scales in which positive words represented a 9 and ratings of 2 or 3 for scales in which the positive words represented a 1. The negative evaluation reversed these ratings. In addition, on the neutral evaluation, the other participant wrote at the bottom of the rating form, "I can understand why a person would think like this." On the negative evaluation, the other participant wrote, "I can't believe an educated person would think like this. I hope this person learns something while at UW [University of Wisconsin]." The person providing the evaluation was ostensibly of the same gender as the participant.

Immediately after the participant finished with the evaluation, the experimenter indicated over the intercom that he needed to collect more baseline brain wave readings. He asked the participant to sit still while he recorded physiological activity. It was at this point that 1 min of EEG data were acquired.

Following the collection of the EEG data, the experimenter explained the taste perception study, which serves as our measure of aggression. He told participants that it is very important for experimenters to remain unaware of the type of tastes to which participants are exposed in taste perception studies. He explained that one way to keep experimenters unaware of the tastes is to have 1 participant assign the tastes to the other participant. He also explained that the participant had been randomly determined to assign the tastes to the other participant and that the other participant would have to drink all that he was given. The experimenter then showed the participant six types of beverages. Each beverage consisted of 11 oz (325 ml) of water with 1, 2, or 3 teaspoons of sugar, apple juice, lemon juice, salt, vinegar, or hot sauce mixed into the water. Thus, each of the six types of beverages had three concentration levels. We explained that most persons find the sugar water most pleasant and the hot sauce most unpleasant and that the other beverages were rated in between these two extremes, with those closer to sugar being more pleasant and those closer to hot sauce being more unpleasant. The beverages were always presented on a tray and in the same order (sugar, apple juice, lemon juice, salt, vinegar, hot sauce), from very pleasant to very unpleasant.

[2] In addition, 2 participants did not correctly follow instructions for the aggression measure, and their aggression data could not be analyzed.

Participants were told to select one of the six types of beverages for the other participant, to pour some of each of the three concentrations into cups, and to cover the cups with lids when done. The participants were also told to label the concentration level on the bottom of each cup. The experimenter indicated that the participants could choose which type of beverage to administer and how much to administer to the other participant. The participants were also given a black sheet to cover the unused beverages when they were finished administering the beverages, to keep the experimenter unaware of the type of beverage the participants chose. We calculated aggression by assigning each beverage a value that corresponded to its unpleasantness, on a scale ranging from −3 (sugar) to 3 (hot sauce). This measure of aggression is similar to a technique developed by other researchers (Lieberman, Solomon, Greenberg, & McGregor, 1999; McGregor et al., 1998).[3]

After participants finished with the administration of the beverages, they were asked to complete questionnaires designed to assess emotions they felt during the experiment. The emotion questionnaire instructed participants to indicate to what extent they felt each feeling during the experiment, on the basis of a scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely*). A similar questionnaire, given at the beginning of the experiment (baseline), asked participants to indicate how they felt at that moment. The affect scales included words designed to assess anger (*angry, bad, irritable, annoyed, agitated, hostile, frustrated*; Cronbach's $\alpha = .64$ for baseline and .91 for state questionnaire), fear (*afraid, scared, nervous, jittery*; Cronbach's $\alpha = .63$ for baseline and .87 for state questionnaire), and positive affect (*good mood, happy, uplifted, alert, active, determined, enthusiastic, excited, inspired, interested, proud, strong, attentive*; Cronbach's $\alpha = .92$ for baseline and .91 for state questionnaire).

EEG Recordings and Analyses

To obtain baseline measures of EEG, we asked participants to relax with their eyes closed or open in one of two alternating orders of 1-min intervals for a total of 8 min, as in previous research (Harmon-Jones, 2000; Tomarken et al., 1992). We also assessed EEG for 1 min following the insult. Participants were asked to keep their head and body as still as possible during the recordings, and they were given instructions over intercom by the experimenter, who was in an adjacent room that contained the amplifiers and computers. To record EEG, we placed six electrodes mounted in a stretch-lycra electrode cap (Electro-Cap, Eaton, OH) on the participant's head using known anatomical landmarks (Blom & Anneveldt, 1982). EEG was recorded from midfrontal (F3/F4), lateral frontal (F7/F8), and parietal (P3/P4) regions of the brain, using the 10–20 international system (Jasper, 1958). A ground electrode was mounted in the cap on the midline between the frontal pole (Fpz) and the frontal site (Fz). The reference electrode was placed on the left ear lobe (A1), and data were also acquired from an electrode placed on the right ear lobe (A2), so that an off-line, digitally derived, averaged ears' reference could be computed. Vertical eye movements (EOG) were recorded from the supra- and suborbit of the left eye to facilitate artifact scoring of the EEG. All electrode impedances were under 5,000 ohms, and homologous sites (e.g., F7 and F8) were within 1,000 ohms of each other. Electro-Gel (Electro-Cap, Eaton, OH) was used as the conducting medium. EEG and EOG were amplified with a Contact Precision Instruments EEG8 amplifier unit (Cambridge, Massachusetts), bandpass filtered (0.1–100 Hz; 60 Hz notch filter enabled), digitized at 500 Hz, and stored onto the hard drive of a Pentium 200 MMX computer. Prior to testing each participant, to assess the technical integrity of the recording system, we ran and inspected a low impedance 0.5 Hz 100 microvolts square wave signal.

The EEG and EOG signals were visually scored on a high-resolution computer monitor, and portions of the data that contained eye movements, muscle movements, or other sources of artifact were removed. Derived averaged-ears reference was used for further data reduction. All artifact-free epochs that were 2.048 s in duration were extracted through a Hamming window (Davidson, Jackson, & Larson, 2000). Contiguous epochs were overlapped by 75% to minimize loss of data due to Hamming window extraction. A fast Fourier transform was used to calculate the power spectra. These power values were averaged across the 2.048-s epochs of a given trial. Total power within the alpha (8–13 Hz) frequency range was obtained. Asymmetry indices (log right − log left alpha power) were computed for lateral–frontal (F7/F8) and parietal sites (P3/P4). Because alpha power is inversely related to cortical activity (Lindsley & Wicke, 1974), higher scores on the indices indicate greater relative left hemisphere activity. For resting baseline, data were averaged across eyes-open and eyes-closed minutes ($M = 637.19$ artifact-free epochs, $SD = 149.45$; all participants had more than 351 artifact-free epochs). For the insult, an average of 90.38 artifact-free epochs ($SD = 25.07$) composed the data, and all participants had more than 10 artifact-free seconds (as recommended by Davidson et al., 1990).

Results

Differences Between Conditions

To test the hypothesis that relative left-prefrontal activity is associated with anger, we first needed to demonstrate that the insult manipulation increased anger. The results demonstrate that anger was increased in the insult condition. Participants in the insult condition reported more anger ($M = 2.01$) than did participants in the no-insult condition ($M = 1.41$), $F(1, 39) = 7.57$, $p < .01$. Conditions did not differ significantly in reported fear or positive affect, though there were tendencies for participants in the insult condition to report less positive affect ($M = 2.75$) and less fear ($M = 1.27$) than did participants in the no-insult condition: For positive affect, $M = 2.99$, $F(1, 39) = 3.10$, $p = .09$; for fear, $M = 1.42$, $F(1, 39) = 1.96$, $p = .17$. In each of the preceding analyses, baseline affect was used as a covariate in an analysis of covariance (ANCOVA; e.g., baseline anger was used as a covariate for the state anger analysis).

Our primary prediction was that the insult manipulation would increase relative left-prefrontal activity. Results support this prediction. Participants in the insult condition showed greater relative left-prefrontal activity ($M = 0.027$) than did participants in the

[3] Our measure of aggression is similar to the hot sauce administration paradigm developed by other researchers. However, the present measure extends the past measure by giving participants more than one type of substance to administer to the other participant. The hot sauce paradigm described previously (Lieberman et al., 1999; McGregor et al., 1998) effectively eliminates several problems associated with past laboratory aggression measures, such as the administration of electric shock (see Lieberman et al., 1999). Although the hot sauce paradigm improves on the shock paradigm, it suffers from the following limitation. Because participants are given only one type of substance (i.e., hot sauce) to administer to the other "participant," they do not have a clear opportunity to choose not to be aggressive. If they were to choose not to administer hot sauce, they might believe that the experimenter would be upset with them, because the taste perception experiment cannot be completed. In contrast, the present paradigm does not suffer from this limitation, because participants who do not intend to behave aggressively can choose a neutral- or pleasant-tasting beverage.

no-insult condition (M = −0.002), $F(1, 39) = 4.26$, $p < .05$.[4] Supporting the regional specificity of this effect, results revealed that participants in the insult condition did not differ from participants in the no-insult condition on asymmetrical parietal activity, $F < 1.0$, $p > .35$. In these analyses, baseline resting frontal (parietal) asymmetry was used as a covariate in an ANCOVA.

In addition, participants in the insult condition were more likely to select an unpleasant-tasting beverage for the other participant (M = 1.33) than were participants in the no-insult condition (M = −0.62), $F(1, 38) = 7.76$, $p < .01$.

Participants in the insult condition showed more anger and relative left-prefrontal activity than did participants in the no-insult condition. In addition, participants in the insult condition engaged in more aggression than did participants in the no-insult condition.

Interaction of Insult-Related Prefrontal Asymmetry and Condition in Predicting Emotional Reactions and Aggression

Does this increase in relative left-prefrontal activity relate to increased anger and aggression? To address these questions, we examined the interactive relationship of insult-related prefrontal asymmetry and condition in predicting emotional reactions and aggression. We performed regression analyses in which resting baseline prefrontal asymmetry, baseline reported affect, condition (effect coded), prefrontal asymmetry immediately after the insult, and the Condition × Prefrontal Asymmetry After the Insult interaction were used to predict reported emotions (anger, fear, positive affect) to the insult and aggression. Individual differences in baseline asymmetry and reported affect were controlled in the regression analyses to assess whether prefrontal asymmetry specific to the insult predicted emotional reactions.

Emotional reactions. In the insult condition, relative left-prefrontal activity related to anger, whereas in the no-insult condition, relative left-prefrontal activity did not relate to anger. These effects were revealed in a significant Condition × Insult-Related Prefrontal Asymmetry interaction, $\beta = .44$, $t(36) = 3.62$, $p < .005$, partial $r = .52$, and in follow-up examinations of the simple relationship between insult-related prefrontal asymmetry and anger within each condition, controlling for baseline prefrontal asymmetry and baseline anger: For the insult condition, $\beta = .64$, $t(23) = 3.31$, $p < .005$, partial $r = .57$; for the no-insult condition, $\beta = -.01$, $t(11) = -0.06$, $p = .95$, partial $r = -.02$. Similar analyses were performed with fear and positive affect as dependent variables, and the interaction of condition and asymmetry was not significant for either fear or positive affect ($ps > .33$).

Aggression. In the insult condition, relative left-prefrontal activity related to aggression, whereas in the no-insult condition, relative left-prefrontal activity did not relate to aggression. These effects were revealed in a significant Condition × Insult-Related Prefrontal Asymmetry interaction, $\beta = .29$, $t(35) = 2.00$, $p = .05$, partial $r = .32$, and in follow-up examinations of the simple relationship between insult-related prefrontal asymmetry and aggression within each condition, controlling for baseline prefrontal asymmetry: For the insult condition, $\beta = .71$, $t(24) = 3.63$, $p < .005$, partial $r = .60$; for the no-insult condition, $\beta = -.10$, $t(10) = -.30$, $p = .77$, partial $r = -.09$. These results demonstrate that relative left-prefrontal activity related to anger and aggression.

Discussion

The research presented here supports the prediction that anger is associated with relative left-prefrontal cortical activity. In conjunction with trait-based research (Harmon-Jones, 2000; Harmon-Jones & Allen, 1998), the present research demonstrates that asymmetrical prefrontal cortical activity reflects motivational direction rather than emotional valence. If asymmetrical prefrontal cortical activity reflected emotional valence, then anger would have related to relative right-prefrontal cortical activity. That the results were significantly opposite to the prediction that was based on models that assume that asymmetrical prefrontal activity reflects emotional valence provides support for models that assume that asymmetrical prefrontal cortical activity reflects motivational direction.

The present research suggests that the consideration of motivational direction is vital to fully understanding emotional processes. Furthermore, it suggests that processes underlying behavioral approach not be equated with positive emotion, contrary to what several current theories posit (e.g., Lang, Bradley, & Cuthbert, 1997; Watson, 2000).

Offensive Aggression and Anger

The idea of anger being related to approach-related aggression is captured in the distinction between offensive and defensive aggression. A number of aggression researchers have pointed to a distinction between these two forms of aggressive behavior and have suggested that offensive aggression is associated with anger, attack, and no attempts to escape, whereas defensive aggression is associated with fear, attempts to escape, and attack only if escape is impossible (Blanchard & Blanchard, 1984; Lagerspetz, 1969; Moyer, 1976). In demonstrating that organisms show offensive aggression, Lagerspetz (1969) found that under certain conditions, mice would cross an electrified grid to attack another mouse. Other research has demonstrated that damage to the amygdala, a brain region involved in defensive behavior, has no effect on offensive aggression but reduces reactivity to nonpainful threat stimuli (Blanchard & Takahashi, 1988; Busch & Barfield, 1974). Further evidence supporting the conceptualization of anger as involved in offensive aggression comes from research on testosterone, which has been found to be associated with anger and aggression in humans (e.g., Olweus, 1986). In this research, testosterone treatments have been found to decrease defensive (fear) responses in a number of species (e.g., Boissy & Bouissou, 1994; Vandenheede & Bouissou, 1993). Taken together, these diverse lines of research suggest that offensive aggression is associated with different neural systems, hormones, and behaviors than those associated with defensive aggression. Moreover, these offensive aggressive behaviors are likely associated with anger (Blanchard & Blanchard, 1984; Moyer, 1976). The present research suggests a possible cortical mechanism involved in offensive aggression.

Conclusion

> But anger is problematic above all other negative affects for its social consequences . . . my anger . . . threatens violence for you, your

[4] Results with midfrontal asymmetry (F3/F4) were similar to, albeit weaker than, those with lateral-frontal asymmetry (F7/F8).

> family, your friends, and above all for our society. Of all the negative affects it is the least likely to remain under the skin of the one who feels it, and so it is just that affect all societies try hardest to contain within that envelope under the skin. (Tomkins, 1991, p. 111)

The present research was designed to test the emotional and motivational functions of asymmetrical prefrontal activity in state emotion. By demonstrating that anger, an approach-related negative emotional state, is related to relative greater left-prefrontal activity, the results provide support for models that posit that the left-prefrontal region is involved in approach motivation and contradict models that posit that the left-prefrontal region is only involved in positive affect. This research reveals important information about the involvement of the left-prefrontal cortex in anger and how changes in this brain region during anger relate to aggression. Of course, approach motivations such as anger involve several brain regions, but the present research establishes the importance of left-prefrontal activity in anger. By understanding basic processes involved in anger, we as a society should be in a better position to explain, predict, treat, and control anger when necessary.

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