Research Article

The Effect of Personal Relevance and Approach-Related Action Expectation on Relative Left Frontal Cortical Activity

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ABSTRACT—*Past research using a variety of methods has suggested that the frontal cortex is asymmetrically involved in the experience and expression of positive (or approach motivational) and negative (or withdrawal motivational) affects, with the left frontal region being involved in positive affects (or approach) and the right frontal region being involved in negative affects (or withdrawal). However, some studies have failed to replicate these effects, leaving many scientists questioning the meaning of the past supportive findings. To examine these inconsistencies in results, we tested the hypothesis that increasing the personal relevance of the stimuli and approach motivational intensity would increase relative left frontal activation. Results supported the predictions. Moreover, by showing the predicted effects with anger-inducing stimuli, the results demonstrated that motivational direction, rather than affective valence, accounts for asymmetrical frontal cortical activity.*

In the past three decades, a large body of research using a diversity of methods has suggested that the frontal cortex is asymmetrically involved in emotive processes, with the left frontal cortex being involved in positive affective experience and expression (or approach motivational processes) and the right frontal cortex being involved in negative affective experience and expression (or withdrawal motivational processes). Evidence supporting this framework comes from studies in which the manipulation of the activation of the left and right frontal cortices produces predicted affective states (George et al., 1996); biofeedback studies in which manipulation of electroencephalographic (EEG) alpha power produces emotional changes (Allen, Harmon-Jones, & Cavender, 2001); studies relating resting EEG alpha power to affective traits (Tomarken, Davidson, Wheeler, & Doss, 1992); and experiments in which manipulating emotions leads to changes in left and right frontal cortical activation, using EEG (Coan, Allen, & Harmon-Jones, 2001) and functional magnetic resonance imaging (fMRI) measurements (Canli, Desmond, Zhao, Glover, & Gabrieli, 1998).

However, some studies have failed to find the predicted asymmetrical frontal cortical effects (for reviews, see, e.g., Canli, 1999; Murphy, Nimmo-Smith, & Lawrence, 2003; Pizzagalli, Shackman, & Davidson, 2003). These failures have led many scientists to question the validity of the idea that different emotions are related to asymmetrical frontal activity. One possible reason for these failures is that these studies were predicated on the idea that asymmetrical frontal cortical activity is related to the experience of emotional valence, and consequently, the researchers predicted that the creation of a positive (or negative) affective state would be sufficient to evoke greater relative left (or right) frontal activity. However, research on anger has suggested that asymmetrical frontal activity is not associated with affective valence, but is instead associated with motivational direction, with approach motivation being associated with left frontal activity and withdrawal motivation being associated with right frontal activity. That is, both correlational and experimental research have demonstrated that anger, a negative but approach-oriented emotion (Carver, 2004; Harmon-Jones, 2003), is related to greater left frontal activity

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(d'Alfonso, van Honk, Hermans, Postma, & de Haan, 2000; Harmon-Jones, 2004; Harmon-Jones & Allen, 1998; Harmon-Jones & Sigelman, 2001).

Another interpretation of these failures to find predicted asymmetrical effects is that the emotional manipulations used were weak (see Pizzagalli et al., 2003). Past research on anger and asymmetrical frontal activity, which produced consistent effects, used stronger emotion manipulations. For example, in these experiments, participants were asked to write an essay on a personally important social issue and then received insulting (or neutral) feedback about their essay and personality from another ostensible participant (Harmon-Jones & Sigelman, 2001; Harmon-Jones, Vaughn, Mohr, Sigelman, & Harmon-Jones, 2004). Also, prior to writing the essay, participants were subtly informed of the possibility of aggressing against the other participant. In both experiments, participants who were insulted showed greater relative left frontal activity than participants who were not insulted. Unlike the experiments that failed to find a relationship between emotion and asymmetrical frontal brain activity, these experiments were characterized by (a) personally involving affective situations and (b) an expectation of action. However, these features were not varied, so it is uncertain whether they led to the predicted asymmetrical frontal activations.

Recent evidence is consistent with the suggestion that the expectancy of action can affect relative left frontal activity. Based on past work in motivation theory and research demonstrating that the expectancy of coping can modify the intensity of motivation (Brehm, Wright, Solomon, Silka, & Greenberg, 1983; Lazarus, 1991), research tested whether a manipulation of the expectancy of action could affect the degree of motivational intensity and relative left frontal cortical activation (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003). All participants were exposed to a communication about an upcoming event that would affect them negatively. This communication was found to cause anger. However, just before hearing the communication, half of the participants were informed of a way they could possibly prevent the occurrence of the negative event at the end of the study, whereas the other half were informed that no action could rectify the situation. Results revealed that participants in the two conditions experienced similar increases in angry feelings, but only those in the action-expectation condition showed the predicted increase in relative left frontal activation.[1] In addition to suggesting that expectation of action increases motivational intensity and relative left frontal cortical activity, these results indicate that the degree of self-reported anger does not necessarily relate to relative left frontal activity (see also Hewig, Hagemann, Seifert, Naumann, & Bartussek, 2004). Thus, it may be the approach or withdrawal component of emotion, rather than the experience of emotion per se, that relates to relative left frontal activity.

Given the past inconsistencies in the research on asymmetrical frontal activity, we felt it important to assess whether the combination of personal relevance and an expectation of approach-related action would increase activation of relative left frontal cortical responses. We also thought it important to extend these ideas to emotional stimuli that are typically used in affective neuroscience research.

To increase the emotional impact of the stimuli, we increased their psychological relevance to the participants. We accomplished this by having participants who were not racist complete a questionnaire measuring racism, so that the salience of their opposition toward racism would be increased. To increase action expectancy, we told participants that they would engage in angry approach-related behavior at the end of the session.

STUDY 1

Method

Participants

Participants were 55 introductory psychology students at the University of Wisconsin–Madison. They participated in exchange for extra credit. Two participants scored below the midpoint of the Attitude Toward Blacks scale, suggesting they were prejudiced; their data were not included in the primary analyses because their admitted prejudice would have prevented them from becoming angry in response to visual depictions of prejudice.

Procedure

After greeting the participant, the experimenter explained that the session would involve a few tasks—completing personality questionnaires and viewing pictures of various types while brain waves were recorded. The participant then completed a packet of questionnaires. We manipulated the *salience of being nonprejudiced* by including in this packet either the Attitude Toward Blacks scale (Brigham, 1993) or a questionnaire that had a similar length and wording and assessed attitudes toward television. Also, we manipulated the *expectancy of angry approach-related action* by giving half of the participants a version of the packet in which the last page instructed them that they would be asked to write an essay "on why you believe prejudice, racism, and hatred are irrational, unfair, and unjust." These instructions also explained, "We are interested in how your responses to the questionnaires relate to your brain wave responses to the pictures. We also plan to use your essay in other research we are conducting that is aimed at reducing prejudice. That is, your essay could be used to assist in reducing prejudice in individuals who are now prejudiced."

[1]Throughout this article, we use the term relative left frontal activation to refer to greater left than right frontal activation, indexed by a difference score. The primary focus in this line of research is on such a metric. However, recent research with large electrode arrays has revealed that approach-related anger evokes both increased left frontal and decreased right frontal activation, which is consistent with the idea that anger is associated with increased approach and decreased withdrawal motivation (Harmon-Jones et al., 2004).

After completing the packet, all participants viewed a series of pictures while EEG was recorded. Four types of pictures were presented in randomized order; there were 16 pictures of each type. Three types were pictures that had been found to evoke negative, positive, or neutral affect in past studies; they were obtained from the International Affective Picture System (Center for the Study of Emotion and Attention, 1995). The fourth type consisted of pictures that might evoke anger in individuals who were opposed to racism and prejudice. Thus, these pictures, which were obtained from the Internet, depicted instances of racism and prejudice (e.g., Ku Klux Klan, Neo-Nazis). Each picture trial consisted of a fixation cross presented for 1 s, a picture presented for 6 s, and an intertrial interval of 14 to 19 s.

After viewing all the pictures once, participants viewed them a second time and rated whether the pictures made them feel pleasant, aroused, and angry (1, *not at all*, to 9, *extremely*). Participants who did not complete the Attitude Toward Blacks scale at the beginning of the study then completed this scale. Finally, participants were questioned about their reactions and told about the purpose of the study.

EEG Recording and Analyses

For EEG recording, 27 electrodes (22 homologous and 5 midline) mounted in a stretch Lycra electrode cap (Electro-Cap, Eaton, OH) were placed on the participant's head using anatomical landmarks. EEG was recorded from the frontal, central, temporal, parietal, and occipital regions of the brain (and regions in between), using the 10% electrode system (Chatrian, Lettich, & Nelson, 1985). The ground electrode was mounted in the cap on the midline between the frontal pole and the frontal site. The reference electrode was placed on the left ear, and data were also acquired from an electrode placed on the right ear. Eye movements were also recorded to facilitate artifact scoring of the EEG. All electrode impedances were under 5,000 Ω, and homologous sites (e.g., F3 and F4) were within 1,000 Ω of each other. EEG and electro-oculogram were amplified with Neuroscan Synamps (Herndon, VA), band-pass filtered (0.1–100 Hz; 60-Hz notch filter enabled), and digitized at 500 Hz onto a computer. Before each session, 400-μv 20-Hz calibration signals were run.

Off-line, EEG was rereferenced to average earlobes, manually scored for movement artifact, and submitted to a regression-based blink-correction procedure (Semlitsch, Anderer, Schuster, & Presslich, 1986). Artifact-free epochs that were 1.024 s in duration were extracted through a Hamming window. Contiguous epochs were overlapped by 75%. A fast Fourier transform was used to calculate the power spectra. Because alpha power is inversely related to cortical activity (Cook, O'Hara, Uijtdehaage, Mandelkern, & Leuchter, 1998; Lindsley & Wicke, 1974), total power within the alpha (8–13 Hz) frequency range was obtained. The power values were log-transformed for all sites, to normalize the distributions.

As in previous research (Tomarken et al., 1992), a frontal asymmetry index (natural log of alpha power on the right minus natural log of alpha power on the left) was computed for 3 s beginning with the onset of each picture,[2] using midfrontal and lateral frontal sites (F3/4, F7/8). For comparison purposes, asymmetry indices for the other sites (Fp1/2, Ft7/8, Fc3/4, T3/4, T5/6, C3/4, Cp3/4, P3/4, and O1/2) were also computed. Because alpha power is inversely related to cortical activity, higher scores on the indices indicate greater relative left-hemisphere activity.

According to the primary hypothesis, the combination of salience of being nonprejudiced and expectancy of approach-related angry action would cause the greatest relative left frontal cortical activation. Because this hypothesis was directional, planned comparisons and one-tailed tests were used to evaluate it.

Results

EEG Alpha

Our primary prediction concerned asymmetrical frontal activity, which was analyzed as a function of salience of nonprejudice (between subjects), expectancy of action (between subjects), and picture type (within subjects). A significant three-way multivariate interaction emerged, $F(3, 46) = 3.15$, $p = .03$, $p_{rep} = .91$, $\eta_p^2 = .17$. Follow-up analyses of the effect of picture type on asymmetrical frontal cortical activation within each of the four between-subjects conditions revealed a significant effect of picture type only in the nonprejudice-salient/expectancy-of-action condition, $F(3, 14) = 8.75$, $p = .002$, $p_{rep} = .98$, $\eta_p^2 = .65$. All other conditions produced nonsignificant effects for picture type, ps $> .40$, p_{rep}s $< .57$ (see Table 1).

A planned comparison (1 vs. 3) pitting the critical condition against the other three conditions (relative left frontal asymmetry to anger picture minus relative left frontal asymmetry to neutral pictures) revealed a significant effect, $t(49) = 2.71$, $p = .009$, $p_{rep} = .97$, $\eta_p^2 = .15$. Moreover, each condition differed from the critical condition, ps $< .032$, p_{rep}s $> .91$.[3]

To examine left and right frontal cortical sites separately, we combined left (and right) midfrontal and lateral frontal sites and then subjected them to a 2 (hemisphere) × 4 (picture type) × 2 (salience of nonprejudice) × 2 (expectancy) multivariate analysis of variance (MANOVA). It produced a significant four-way interaction, $F(3, 46) = 3.15$, $p = .03$, $p_{rep} = .91$, $\eta_p^2 = .17$. To follow-up this interaction, we performed a 2 (hemisphere) × 4 (picture type) repeated measures MANOVA within each of the

[2]Only EEG data from 0 through 3 s after onset of the picture were processed because on some trials, startling noises were presented at 3.5 s. Analyses concerning startles are not reported in this article.

[3]Similar analyses were conducted on all asymmetrical sites. A few significant three-way interactions resulted with the pattern of means similar to that just reported, but these interactions were not replicated in Study 2, so they are not discussed here. The one that was replicated was Ft7/8. In both studies, in the critical condition, anger pictures produced significantly greater left frontal temporal activity than all other pictures.

TABLE 1

Mean Frontal Asymmetry as a Function of Condition and Picture Type in Study 1

	Condition			
Picture type	Low NP salience, low action expectancy	Low NP salience, high action expectancy	High NP salience, low action expectancy	High NP salience, high action expectancy
Anger	0.0090 (0.20)	−0.0378 (0.17)	−0.0108 (0.16)	0.1042 (0.17)
Negative	−0.0076 (0.23)	−0.0153 (0.18)	0.0346 (0.16)	0.0144 (0.18)
Positive	0.0174 (0.24)	0.0190 (0.16)	0.0607 (0.16)	0.0300 (0.17)
Neutral	0.0020 (0.20)	−0.0564 (0.10)	−0.0016 (0.17)	−0.0035 (0.18)

Note. Standard deviations are given in parentheses. Greater positive values indicate greater relative left frontal activity. NP = nonprejudice.

four between-subjects conditions. Results revealed that only the nonprejudice-salient/expectancy-of-action condition showed a significant two-way interaction, $F(3, 14) = 8.75$, $p = .002$, $p_{rep} = .98$, $\eta_p^2 = .65$. All other conditions produced nonsignificant interactions ($ps > .45$, $p_{rep}s < .54$). Within the critical condition, only during anger pictures did left and right frontal sites differ from each other ($p < .001$, $p_{rep} = .99$; all other $ps > .20$, $p_{rep}s < .72$). Also, left frontal activation to anger pictures was greater than left frontal activation to neutral pictures ($p < .001$, $p_{rep} = .99$), but did not differ from left frontal activation to negative and positive pictures. Right frontal activation to anger pictures was less than right frontal activation to all other picture types ($ps < .05$, $p_{rep}s > .88$). In addition, scores on the Attitude Toward Blacks scale were not related to relative left frontal activity while viewing anger pictures in this or any other condition.

Self-Reported Affect

A 2 (expectancy) × 2 (salience of nonprejudice) × 4 (picture type) × 3 (emotion rating) revealed a nonsignificant interaction, $p > .10$, $p_{rep} = 81$. To more thoroughly examine the effects of the manipulations on self-reported anger, we performed some further analyses. The 2 (expectancy) × 2 (salience of nonprejudice) × 4 (picture type) and the 2 (expectancy) × 4 (picture type) interactions were nonsignificant, $ps > .16$, $p_{rep}s < .76$. However, the 2 (salience of nonprejudice) × 4 (picture type) interaction was significant, $F(3, 44) = 4.83$, $p = .005$, $p_{rep} = .97$, $\eta_p^2 = 25$; for the anger pictures, anger ratings were greater if nonprejudice was salient rather than not salient, $ps < .02$, $p_{rep}s > .93$. No interactions involving rated arousal or pleasantness were significant, $ps > .40$, $p_{rep}s < .57$ (see Table 2).

For pleasantness ratings, a main effect of picture type resulted, $F(3, 48) = 172.38$, $p < .001$, $p_{rep} = .99$, $\eta_p^2 = .92$. Ratings for all emotional pictures differed from ratings for neutral pictures. Also, positive pictures were rated most pleasant, and negative and angry pictures were rated least pleasant; ratings for the negative and angry pictures did not differ ($p > .40$, $p_{rep} = .57$; see Table 3).

For arousal ratings, a main effect of picture type resulted, $F(3, 48) = 112.32$, $p < .001$, $p_{rep} = .99$, $\eta_p^2 = .88$.[4] Each picture type differed from every other picture type, all $ps < .05$, $p_{rep}s > .88$, with the intensity of arousal highest for positive pictures and decreasing for negative pictures, anger pictures, and neutral pictures, in that order. Given the fact that arousal ratings were not independent of valence ratings (i.e., they were positively correlated; see also Amodio, Harmon-Jones, & Devine, 2003), it is difficult to know how to interpret these effects (see Table 3).

TABLE 2

Mean Anger Ratings as a Function of Picture Type and the Salience of Nonprejudice (NP) in Study 1

	Picture type			
Condition	Negative	Positive	Neutral	Anger
Low NP salience	$2.88\ (1.49)_a$	$1.07\ (0.17)_a$	$1.15\ (0.26)_a$	$4.63\ (1.66)_a$
High NP salience	$3.18\ (1.74)_a$	$1.14\ (0.23)_a$	$1.12\ (0.20)_a$	$5.91\ (1.86)_b$

Note. Standard deviations are given in parentheses. Within a column, means with different subscripts differ at $p < .05$, $p_{rep} > .88$. Greater values indicate greater intensity of self-reported anger.

STUDY 2

Study 2 was designed to assess whether the primary effect in Study 1 was replicable. In addition, it was designed to examine whether individual differences in prejudice would predict relative left frontal activation in response to the anger-producing racist pictures. In other words, if the effect of action expectation and personal relevance in producing left frontal activation was indeed due to the processes suggested, individuals who are particularly low in prejudice should be especially likely to evidence greater relative left frontal activity while viewing the anger pictures. Because of the small sample, it was not possible to adequately address this issue in Study 1.

[4]Degrees of freedom differ between various analyses because some participants did not complete all affect items.

TABLE 3

Mean Pleasantness and Arousal Ratings as a Function of Picture Type in Study 1

	Picture type			
Rating	Negative	Positive	Neutral	Anger
Pleasantness	$1.37\ (0.61)_a$	$5.41\ (1.30)_b$	$2.90\ (1.20)_c$	$1.32\ (0.71)_a$
Arousal	$3.98\ (2.31)_a$	$4.64\ (1.49)_b$	$1.78\ (0.95)_c$	$3.21\ (1.98)_d$

Note. Standard deviations are given in parentheses. Within a row, means with different subscripts differ at $p < .05$, $p_{rep} > .88$. Greater values indicate greater intensity of self-reported pleasantness or arousal.

Method

Participants were 56 University of Wisconsin introductory psychology students who participated in exchange for extra credit in their class. Three participants scored below the midpoint of the Attitude Toward Blacks scale and were therefore removed from the within-subjects analyses in which we tested whether the anger pictures evoked greater relative left frontal activity than the other picture types. The methods were identical to those used in Study 1, except that only the nonprejudice-salient/expectancy-of-action condition was run.

Results

EEG Alpha

For asymmetrical frontal cortical activity, a planned comparison (1 vs. 3) pitting the anger picture type against the three other types revealed a significant effect, $t(52) = 2.57$, $p = .01$, $p_{rep} = .95$, $\eta_p^2 = .13$. In addition, asymmetrical frontal cortical activity for anger pictures differed from asymmetrical frontal cortical activity for each of the other picture types, ps $< .04$, p_{rep}s $> .89$ (see Table 4).

Next, separate indices of right (F4, F8) and left (F3, F7) frontal activity were analyzed. A 4 (picture) × 2 (hemisphere) MANOVA on these indices revealed an interaction, $F(3, 50) = 2.37$, $p = .08$, $p_{rep} = .84$, $\eta_p^2 = .12$. Follow-up simple-effects tests revealed that left frontal activity was greater for anger pictures than all other pictures (ps $< .025$, p_{rep}s $> .92$). In addition, right frontal activity was lower for anger pictures than negative pictures ($p = .02$, $p_{rep} = .93$) and neutral pictures ($p = .05$, $p_{rep} = .88$), but not positive pictures ($p = .86$, $p_{rep} = .22$).

Self-Reported Affect

A 3 (rating type) × 4 (picture type) MANOVA revealed a significant interaction, $F(6, 43) = 97.10$, $p < .001$, $p_{rep} = .99$, $\eta_p^2 = .93$. We followed up by conducting a separate ANOVA for each type of rating. For anger ratings, a significant effect emerged, $F(3, 46) = 105.01$, $p < .001$, $p_{rep} = .99$, $\eta_p^2 = .87$; reported anger was significantly greater for anger pictures than all other pictures, and negative pictures evoked more anger than neutral and positive pictures. A significant effect emerged for pleasantness ratings as well, $F(3, 46) = 197.33$, $p < .001$, $p_{rep} = .99$, $\eta_p^2 = .93$; reported pleasantness was greater for positive pictures than neutral pictures, and lower for negative and anger pictures than for neutral pictures. Moreover, anger and negative pictures did not differ significantly in pleasantness. Finally, for arousal ratings, a significant effect emerged, $F(3, 46) = 70.32$, $p < .001$ $p_{rep} = .99$, $\eta_p^2 = .82$; all valenced pictures were rated as more arousing than neutral pictures. In addition, positive pictures were rated as more arousing than negative and anger pictures. Finally, ratings for negative and anger pictures did not differ (see Table 4).

Relation Between Attitudes Toward Blacks and Responses to Anger-Inducing Pictures

To examine whether individual differences in attitudes toward racism related to asymmetrical frontal cortical responses to the anger-inducing pictures, we performed a regression analysis in which asymmetrical frontal activity in response to the anger pictures served as the criterion and asymmetrical frontal activity in response to the neutral pictures and attitudes toward Blacks served as predictors. Asymmetrical activity in response to the neutral pictures was included to statistically control for individual differences in asymmetrical activity. The analysis was significant overall, $F(2, 52) = 19.66$, $R^2 = .43$, $p < .001$, $p_{rep} = .99$. Asymmetry in response to neutral pictures was related to asymmetry in response to anger pictures, $\beta = .60$, $t(52) = 5.75$,

TABLE 4

Mean Emotion Ratings and Frontal Asymmetry as a Function of Picture Type in Study 2

	Picture type			
Measure	Negative	Positive	Neutral	Anger
Anger	$3.13\ (1.49)_a$	$1.15\ (0.36)_b$	$1.12\ (0.19)_b$	$6.11\ (2.00)_c$
Pleasant	$1.66\ (0.60)_a$	$5.94\ (1.33)_b$	$3.06\ (1.34)_c$	$1.38\ (0.59)_a$
Arousal	$4.06\ (1.95)_a$	$4.95\ (1.79)_b$	$1.74\ (0.83)_c$	$3.72\ (2.08)_a$
Frontal asymmetry	$0.0677\ (0.16)_a$	$0.0780\ (0.17)_a$	$0.0903\ (0.17)_a$	$0.1264\ (0.18)_b$

Note. Standard deviations are given in parentheses. Within a row, means with different subscripts differ at $p < .05$, $p_{rep} > .88$.

$p < .001$, $p_{rep} = .99$, $\eta_p^2 = .60$, and, more important, score on the Attitude Toward Blacks scale was related to asymmetry in response to anger pictures, $\beta = .21$, $t(52) = 2.01$, $p < .05$, $p_{rep} = .88$, $r_p = .21$. Thus, a more positive attitude toward Blacks was associated with greater relative left frontal activation to the racism-related anger-inducing pictures. A similar regression analysis in which rated anger in response to racist pictures was predicted by attitudes toward Blacks and anger in response to neutral pictures revealed that score on the Attitude Toward Blacks scale was related to rated anger, $\beta = .32$, $t(48) = 2.33$, $p = .02$, $r_p = .32$; overall $F(2, 48) = 2.83$, $R^2 = .11$, $p = .07$.

GENERAL DISCUSSION

Results from Study 1 supported the prediction that an increase in the personal relevance of the stimuli coupled with the expectation of approach-related action would increase relative left frontal activity in response to anger-producing pictures. These manipulations increased relative left frontal activity because they increased the approach motivation associated with anger. Results from Study 2 replicated this critical effect and further showed that greater opposition to racism was associated with more relative left frontal activation in response to the pictures depicting instances of racism. These results provide further evidence that the stimuli evoked approach-related anger, particularly for individuals opposed to the racism shown in the pictures.

Taken together with past research, the current results suggest that the weakness of the emotional stimuli used in the past may have been partially responsible for the failure of previous studies to find predicted asymmetrical frontal activations. Past studies used general stimuli assumed to evoke similar emotions in all participants. In the present studies, we used specifically evocative stimuli; participants who were opposed to racism were exposed to pictures depicting racism. By showing pictorial stimuli depicting instances of racism and hatred to individuals who were opposed to racism and also making these individuals more aware of their nonprejudiced attitudes, we were able to increase the emotional impact of the stimuli, as revealed by the findings for self-report anger in Study 1. However, the increase in experienced emotional impact by itself did not cause an increase in relative left frontal activity in response to the anger pictures. The increased salience of possible approach-related behaviors was also needed to cause greater relative left frontal activity.

The results of Study 1 are consistent with past research in that the manipulation of an angry approach-related action expectancy did not affect the reported experience of anger (Harmon-Jones et al., 2003). That is, past research on anger has revealed that the reported intensity of anger does not always relate directly to asymmetrical frontal activity. Coupled with this past research, the present research suggests that asymmetrical frontal cortical activity taps the intensity of motivational direction. Although motivation is inevitably important in regulating behavior, it does not appear to vary directly with reported emotional experience. In other words, the self-reported or experienced intensity of emotion may not relate to the degree of approach or withdrawal motivation evoked. Many emotions have a motivational component, but it may not be directly related to experienced emotional intensity.

Although the results of Study 1 suggest that personal relevance and the expectation of approach action enhance the effects of affective manipulations on asymmetrical frontal activity, these results should not be taken to indicate that such explicit manipulations of personal relevance and action expectancy are always necessary. Such manipulations 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) without any explicit manipulations of personal relevance or action expectancy. Across all participants, relative left frontal activity did not differ as a function of picture type (anger, negative, positive, neutral). However, individual differences in trait anger correlated positively with relative left frontal activity in response to the anger-inducing pictures, controlling for activity in response to neutral pictures (Harmon-Jones, in press). This result would assist in explaining the inconsistencies observed in past studies. That is, aspects of the stimuli, context, or personality characteristics may increase the degree to which emotions evoke motivations to approach or withdraw.

In sum, the present research strongly suggests that asymmetrical frontal cortical activity is related to motivational direction and not affective valence. A greater empirical and theoretical consideration of motivational direction and its independence from affective valence will assist researchers in understanding emotions, their neural underpinnings, and their consequences.

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