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The Effect of Manipulated Sympathy and Anger on Left and Right Frontal Cortical Activity

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The present research extended past research demonstrating that approach-motivated anger is associated with greater left than right frontal cortical activity. Because past research had examined difference scores between left and right frontal activity, it was unable to test whether approach-motivated anger increased left activity, decreased right activity, or both. In addition, the present research examined a potential moderator of the effect of insult on left frontal activity. That is, it tested whether sympathy for an insulting person would reduce the left frontal activity that occurs following being insulted. Results indicated that left frontal activity was increased and right frontal activity was decreased by the insult. Moreover, these effects were inhibited when high levels of sympathy were first aroused.

Left frontal cortical activity is associated with approach motivation, emotion, and behavior, whereas right frontal cortical activity is associated with withdrawal motivation, emotion, and behavior (Coan & Allen, 2003). The negative emotion of anger, which is *often* associated with approach motivation, is also related to relatively greater left frontal activity. That is, greater left frontal activity during resting baseline is correlated positively with trait anger (Harmon-Jones & Allen, 1998). Also, induced anger causes an increase in relatively greater left than right frontal activity (Harmon-Jones & Sigelman, 2001). Moreover, increased relative left frontal activity is associated with increased self-reported anger and behavioral aggression (Harmon-Jones & Sigelman, 2001). Finally, increased left frontal cortical activity is greater when individuals expect to be able to "go toward" the source of the anger, and it relates to behavior aimed at resolving the anger-producing situation (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003). If individuals expect to be unable to approach the source of the anger, they do not evidence an increase in left frontal activity (Harmon-Jones et al., 2003), even though the level of reported anger remains high. These findings suggest that reported anger does not tap approach motivation as well as left frontal activity.

One limitation of the past state anger-frontal asymmetry research is that only the difference between activity in the left and right frontal cortices was examined. This analytical approach was necessary because there were too few scalp electrodes to derive separate estimates of left and right frontal activity (Wheeler, Davidson, & Tomarken, 1993). Thus, one purpose of the present research was to examine whether anger increased left frontal activity, decreased right frontal activity, or both. Such an analysis is important, as it would shed light on whether state anger increases approach motivation (and left frontal activity), decreases withdrawal motivation (and right frontal activity), or both.

A second purpose of the present research was to examine whether a variable thought to reduce aggressive motivation would also reduce relative left frontal

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activity. Such a finding would be important, as it would further suggest that the increase in relative left frontal activity observed after anger arousal was due to approach motivation and not some other process. One variable that may reduce aggressive motivation is sympathy for the insulting person. In reviewing the sympathy and aggression research, Miller and Eisenberg (1988) concluded that sympathy was negatively related to aggression, in correlational designs.

The present research addressed these issues by manipulating sympathy and anger using procedures developed in past research (e.g., Batson, 1991, 1998; Harmon-Jones & Sigelman, 2001). Participants were induced to experience low or high levels of sympathy for another person, who then insulted them or not. Electroencephalography (EEG) was assessed immediately after the insult, and then self-reported hostile attitudes and anger were assessed. We predicted that within the low-sympathy conditions, the insult would cause greater relative left frontal activity, replicating past research (Harmon-Jones & Sigelman, 2001). We also predicted that the insult would cause an increase in left frontal activity and a decrease in right frontal activity, because the insult would increase approach motivation and decrease withdrawal motivation. Finally, we predicted that high sympathy would reduce the effects of insult on left and right frontal activity. For hostile attitude and anger, we predicted a similar pattern of results, with participants in the low-sympathy–insult condition demonstrating greater hostile attitudes and anger than those in the other three conditions.

Method

Participants

Seventy-nine right-handed introductory psychology students (53 women) participated for extra credit. Each participant was randomly assigned to condition; the experimenter was blind to condition. For EEG data, 71 participants were available, because 8 participants were missing EEG data because of high impedances or equipment problems. Six more participants doubted the cover story and their data were removed prior to analyses (3 from low sympathy–insult and 3 from high sympathy–insult). Gender of participant did not produce any significant effects.

Procedure

After informed consent was obtained, baseline brain activity was recorded for 8 min. Then, participants completed an emotion questionnaire, which asked them to indicate how they currently felt (see below).

Participants were told that the study concerned personality, perception, and brain activity, and that they and another student would be writing an essay and evaluating each other on the basis of the essays (in actuality, no other student was involved in the study). Participants were told to write a persuasive essay arguing either for or against a 10% tuition increase. They were given 10 min to write, and then the experimenter left the room to retrieve the other person's essay. They were informed that they would have an opportunity to evaluate the other person after receiving feedback on their essay so they would know of an opportunity to "retaliate" (e.g., Harmon-Jones et al., 2003).

Sympathy manipulation. The experimenter handed participants a folder containing a reading perspective, an essay, and a questionnaire. The reading perspective instructions informed them to remain completely objective (low sympathy) or to try to imagine how the other person must feel (high sympathy). When participants finished reading the instructions, they read the essay written by the other participant. This essay described the struggle that a person had gone through after being diagnosed with multiple sclerosis.

Insult manipulation. The experimenter then left the room a second time to retrieve the evaluation of the participants' essay. This evaluation contained either neutral comments (no insult) or insulting comments (insult). The experimenter looked at the participant's essay to see whether they wrote for or against a tuition increase and then assigned them to an evaluation.

Next, a 2-min recording of EEG occurred. Then, participants completed a questionnaire that included items to assess impressions of the other person (how likable, friendly, and nice, on a scale ranging from 1 = [*very likable, friendly, nice*] to 9 = [*very unlikable, unfriendly, mean*]; Cronbach's α = .96). Finally, they completed another emotion questionnaire, which was positioned after the impression measure, as research has suggested that the completion of emotion questionnaires can reduce hostile evaluations (e.g., Berkowitz, Jaffee, Jo, & Troccoli, 2000). The emotion questionnaires included items, in a random order, to assess happiness (good mood, happy); activated positive affect (active, alert, determined, enthusiastic, excited, inspired, interested, proud, strong); sympathy (sympathetic, compassionate, tender, moved, and soft-hearted); sadness (depressed, sad, down); distress

(upset, distressed, stressed, nervous); and anger (angry, agitated, irritated, frustrated, hostile). All indexes were internally consistent (Cronbach's αs > .77). Participants were asked to rate how much they felt each emotion at that moment on a 9-point scale (0 = *not at all,* 8 = *the most in my life*). Finally, participants were debriefed.

EEG Assessment and Analyses

Baseline EEG was measured for 8 min. Immediately following the reading of the feedback, EEG was assessed for 2 min. To record EEG, 14 electrodes mounted in a stretch-lycra electrode cap (Electro-Cap, Eaton, OH) were placed on the participant's head using known anatomical landmarks (Blom & Anneveldt, 1982). Electrodes were placed on the midfrontal (F3, F4), lateral frontal (F7, F8), temporal (T3, T4, T5, and T6), central (C3, C4, and Cz), and parietal (P3, P4, and Pz) scalp sites. Analyses of frontal activity focused on F7 and F8, because research has revealed these sites to be more sensitive to the effects of anger manipulations (Harmon-Jones & Sigelman, 2001). A ground electrode was mounted in the cap near the frontal pole. The reference electrode was placed on the left ear (A1), and data were acquired from an electrode placed on the right ear (A2), so that an offline, digitally derived, averaged ears' reference could be computed. Vertical eye movements were recorded from the supra- and sub-orbit of the left eye to facilitate artifact scoring of the EEG. All electrode impedances were under 5,000 Ω, and homologous sites were within 1,000 Ω of each other. Electro-Gel (Eaton, OH) was the conducting medium. Signals were amplified with Contact Precision Instruments EEG8 amplifier units (Cambridge, MA), bandpass filtered (0.1–100 Hz; 60-Hz notch filter enabled) and digitized at 500 Hz.

Portions of the data that contained eye movements, muscle movements, or other artifacts were removed manually. All artifact-free epochs 1.024 s in duration were extracted through a Hamming window. Contiguous epochs were overlapped by 75% to minimize loss of data because of windowing. A fast Fourier transform (FFT) was used to calculate the power spectra. These power values were averaged across epochs of a given trial. Total power within the alpha (8–13 Hz) frequency range was obtained. Asymmetry indexes (log right – log left alpha power) were computed for all homologous sites. The above procedures are consistent with those recommended by EEG researchers (Davidson, Jackson, & Larson, 2000). Because alpha power is inversely related to cortical activity (Cook, O'Hara, Uijtdehaage, Mandelkern, & Leuchter, 1998), higher scores on the indexes indicate greater relative left hemisphere activity. For resting baseline, data were averaged across eyes-open and eyes-closed minutes (M = 827.42 artifact-free epochs, SD = 105.91; all participants had greater than 511 artifact-free epochs). For the other recording, an average of 159.57 artifact-free epochs (SD = 56.98) composed the data, and all participants had greater than 33 artifact-free epochs.

Results

We tested predicted effects using planned comparisons (Rosenthal, Rosnow, & Rubin, 2000); thus, tests involving predicted effects are one-tailed. Because we predicted the low-sympathy–insult condition to evidence greater left (and lesser right) frontal cortical activity, greater hostility, and greater anger than each of the other conditions, we performed one-versus-three comparisons. In conducting tests with cortical activity and self-reported emotions, we statistically adjusted for baseline responses to reduce variance and increase the power of our statistical tests.[1]

Asymmetry Indexes

We predicted that the insult would cause participants to have greater relative left frontal activity, but that sympathy would reduce this activity to the level of the no-insult conditions. We tested this prediction in a one- (low sympathy–insult) versus-three (other conditions) contrast and in follow-up tests. The one-versus-three contrast was significant, $F(1, 66) = 13.13$, $p < .001$, and the three other conditions did not differ from each other, $F(2, 52) = 0.22$, $p = .81$. Moreover, each condition differed from the low-sympathy–insult condition ($ps < .001$, one-tailed). See Table 1 for means for all significant effects. T1

Analyses of the other asymmetry indexes revealed no significant effects ($ps > .11$), consistent with past research (Harmon-Jones & Sigelman, 2001).

Analyses of Left and Right Hemispheres Separately

The previous analyses used asymmetry indexes, which provide information about the difference be-

[1] Degrees of freedom differ in places either because a participant did not respond to all items on questionnaires or because one participant had an electrode used in computing whole head power that had high impedance.

Table 1
Condition Means

~~Condition~~	No insult		Insult	
	Low sympathy	High sympathy	Low sympathy	High sympathy
Sympathy	3.74_A	4.26_B	2.56_C	3.23_A
Anger	1.35_A	1.18_A	2.68_B	3.01_B
PA	3.40_A	$3.74_{A,C}$	4.36_B	$4.03_{B,C}$
Hostile attitudes	3.21_A	2.57_A	6.91_B	5.98_C
F7/8 Asymm.	0.0003_A	-0.0206_A	0.0812_B	-0.0079_A

Note. Within rows, means with different subscripts differ at $p < .05$. PA = activated positive affect; F7/8 Asymm. = lateral frontal asymmetry, with greater scores equivalent to greater relative left frontal activity. All other indexes are scored such that greater scores equal more of the construct.

tween left and right activity. These indexes are useful because they control for individual differences in skull thickness and volume conduction, which could produce differences in alpha power. To assess the effects of left and right hemispheres separately, individual differences in skull thickness and volume conduction need to be controlled. Such control can be accomplished using regression analyses in which alpha power at one site is regressed onto alpha power at all sites and alpha power at the homologous site (Wheeler et al., 1993). For these analyses, alpha power at each lateral frontal site served as the criterion. When interpreting these results, it is important to recall that increased alpha power reflects decreased cortical activity.

For left lateral frontal activity, the one- (low sympathy–insult) versus-three (all other conditions) comparison was significant, $F(1, 65) = 10.20$, $p < .005$, and each condition differed from the low-sympathy–insult condition ($ps < .005$). For right lateral frontal activity, the one-versus-three comparison was significant, $F(1, 65) = 9.26$, $p < .005$, and each condition differed from the low-sympathy–insult condition ($ps < .005$, one-tailed).[2,3] See figure 1. These results are consistent with the hypotheses.[4]

Self-Reported Emotions After Insult Manipulation

Sympathy was greater in the high-sympathy conditions than in the low-sympathy conditions, $F(1, 73) = 4.12$, $p = .05$ (two-tailed), even though sympathy was measured after the insult manipulation. In addition, sympathy was greater in the no-insult conditions than in the insult conditions, $F(1, 73) = 14.47$, $p < .001$ (two-tailed). The interaction was not significant ($p > .80$).

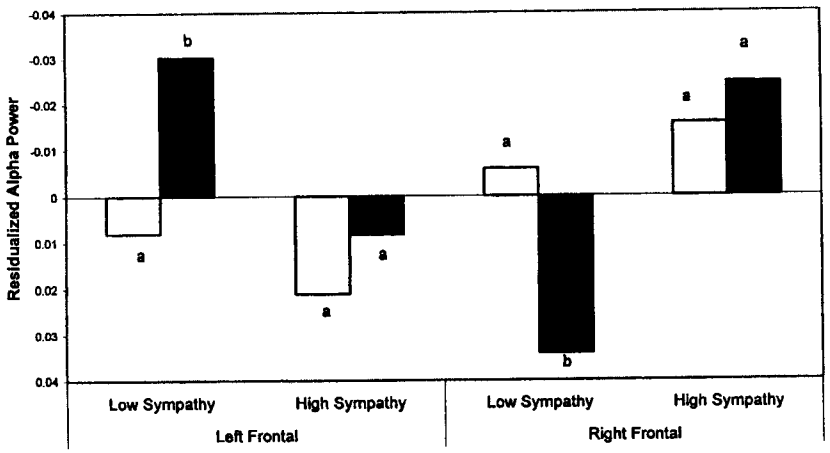
For anger, the one- (low sympathy–insult) versus-three (all other conditions) comparison was significant, $F(1, 74) = 4.97$, $p < .02$ (one-tailed); however, a one-way analysis of variance (ANOVA) of the three other conditions revealed remaining variance, $F(2, 54) = 13.07$, $p < .001$, as the high-sympathy–insult condition produced more anger than the no-insult conditions ($ps < .01$). Moreover, follow-up comparisons pitting each condition against the low-sympathy–insult condition revealed that the two insult conditions did not differ from each other ($p > .80$). Thus, the hypothesis for anger was not supported.

Next, we explored whether other self-reported emotions differed between conditions, using 2 (sympathy) × 2 (insult) ANOVAs. Activated positive affect was greater in the insult conditions than in the no-insult conditions, $F(1, 73) = 8.71$, $p < .005$ (two-tailed). Fear, distress, sadness, and happiness did not

[2] The planned comparisons on each of the frontal cortical indexes produced similar and significant effects on each minute. Moreover, the three other conditions did not differ from each other in the analysis of left or right frontal activity ($ps > .62$).

[3] Analyses conducted without the covariate indicated that all significant effects remained significant and that there were no significant differences between conditions in baseline responses.

[4] Why did participants in the high-sympathy–no-insult condition not evidence increased left frontal activity? According to the reasoning underlying this question, these participants may have been approach motivated to help the target. However, we did not predict increased left frontal activity in these participants, because electroencephalography was not measured immediately after the sympathy manipulation and because they did not know of an opportunity to help the target. Past research has demonstrated that left frontal activity increases only when individuals expect to be able to take approach-oriented action.



AU1

Figure 1. Left and right lateral frontal residualized alpha power as a function of condition (analysis of covariance-adjusted means). More negative means indicate greater cortical activity (i.e., the inversion of the scores on the *y* axis). Within hemispheres, bars with different letters are significantly different at $p < .005$. Bars with the same subscript are not significantly different. Open bars = no insult; solid bars = insult.

differ as a function of condition (*p*s > .10). That insult increased activated positive affect is consistent with the idea that anger would increase approach motivation (as activated positive affect has been described as a measure of approach motivation; Watson, 2000). It is possible that the increased activated positive affect, which does not necessarily tap feelings of pleasure,[5] was an ego-defensive reaction. However, Harmon-Jones and Sigelman (2001) did not find that insult increased activated positive affect.

Hostile Attitude

We predicted that the insult would cause participants to have hostile attitudes toward the target person, but that sympathy would reduce this hostility. We tested these predictions using a one- (low sympathy–insult) versus-three (other conditions) contrast and follow-up comparisons. The one-versus-three contrast was significant, $F(1, 73) = 64.46$, $p < .001$. However, there was remaining variance among the three other conditions, $F(2, 57) = 35.51$, $p < .001$ (the no-insult conditions produced less hostility than the high-sympathy–insult condition, *p*s < .01). Most important, each condition was significantly different from the low-sympathy–insult condition (*p*s < .03, one-tailed).

General Discussion

The present research demonstrated that insult increased left frontal activity and decreased right frontal activity and that high levels of sympathy eliminated this effect. It is important to note that left frontal activity is not only associated with approach motivation. Indeed, studies have revealed that left frontal activity is associated with language, semantic memory retrieval, and episodic memory encoding (Cabeza & Nyberg, 2000). However, it does not seem plausible that these cognitive processes provide alternative explanations for why insults and frustrations increase left frontal activity, why self-reported anger relates to left frontal activity in these conditions, why individual differences in trait anger relate to left frontal activity, and why individual differences in approach motivation sensitivity moderate the effects of frustration on left frontal activity (for a review of these results, see Harmon-Jones, 2003). Moreover, the cognitive processes found to be associated with left frontal activity were associated only with increased left frontal activity and not decreased right frontal activity (Cabeza & Nyberg, 2000). Thus, it seems reasonable to conclude that the manipulation of sympathy reduced the greater left frontal activity typically increased by angering events.

Self-Reported Anger, Hostile Attitudes, and Approach Motivation

Self-reported anger did not differ between the low-sympathy–insult and high-sympathy–insult condi-

[5] Analyses revealed that the active, alert, determined, proud, and strong items were more intense in the insult condition than in the no-insult condition (*p*s < .05), but the enthusiastic, excited, inspired, and interested items were not.

tions, even though left (and right) frontal activity did. These results are conceptually consistent with the results of Harmon-Jones et al. (2003), who found that a manipulation of coping potential affected left frontal activity but not self-reported anger. Taken together, the results suggest that left frontal activity may index approach motivation more precisely than self-reported anger. Moreover, these results suggest that anger may not always relate to approach motivation. That is, some types of anger may evoke withdrawal motivation, and some may not evoke approach or withdrawal motivation.

Hostile attitudes differed between the low-sympathy–insult and high-sympathy–insult conditions in planned comparisons, but the analyses suggested a main effect of insult. This pattern of results was different than that observed for left frontal activity. In other words, the sympathy manipulation was not as effective at reducing hostile attitudes as it was at reducing left frontal activity in response to the insult. Why were hostile attitudes in the high-sympathy–insult condition not reduced to the level of the two no-insult conditions? It is important to note that as an insult, participants were given by the "other participant" an average rating of 2.83 on their personality (on a 9-point scale where 1 is the negative and 9 is the positive end of scale). They then had their EEG recorded for 2 min and then completed the hostile attitude questionnaire, on which the low-sympathy–insult condition reported a mean of 6.91 and the high-sympathy–insult condition reported a mean of 5.98 (where 9 = *extremely negative*). Reversing the hostile attitudes means to make them similar (in direction) to the feedback scores makes them 3.09 and 4.02. In other words, the low-sympathy–insult condition rated the insulting individual almost identical to how they themselves were rated by her or him (3.09 vs. 2.83, $p = .44$). In contrast, the high-sympathy–insult condition rated the insulting individual more positively than they themselves had been rated by her or him (4.02 vs. 2.83, $p = .002$). Consequently, the insult manipulation might have anchored participants' starting point for hostile attitudes, which made it difficult for our sympathetic participants (who probably have relatively positive self-concepts) to evaluate the insulter extremely more positively than they themselves were evaluated by him or her. Therefore, the effect of high sympathy on hostile attitude following the insult may have been partly driven by this anchoring effect, which prevented the hostile attitudes measure from producing the same pattern of results as left frontal activity. Future studies should assess approach motivation with more direct psychological measures.

Examination of Separate Indexes of Left and Right Frontal Activity

The present research was also able to extend the previous research on anger and relative left frontal activity. In the previous research, only six channels of EEG were collected, leaving us unable to examine the effects of left and right frontal sites separately. For the present research, we were able to record 14 channels of EEG, which allowed us to use statistical methods of controlling for the extraneous factors that could influence EEG alpha activity. We found that the insult increased left frontal activity and decreased right frontal activity. Examination of the correlation between left and right frontal cortical activity (i.e., the change in each frontal cortical region from baseline to after feedback) revealed that, within individuals, the left and right frontal cortices were reciprocally activated ($r = .60$, $p < .001$). Such findings suggest that the type of anger evoked in the present context increases approach inclinations and simultaneously decreases withdrawal inclinations.

Conclusion

The present results suggest that interpersonal insult increases left frontal activity and decreases right frontal activity. Moreover, the present research suggests that a manipulation predicted to reduce approach aggressive motivation—sympathy—can reduce the relative left frontal cortical activity that has been found to be increased by anger. The reported research shows one way in which the hypotheses and methods of social psychology and affective neuroscience can be fruitfully integrated.

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