APPROACH- AND WITHDRAWAL-ORIENTED RESPONSES TO SOCIAL REJECTION: THE ROLE OF ASYMMETRICAL FRONTAL CORTICAL ACTIVITY

A Thesis

by

CARLY KATHRYN PETERSON

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2009

Major Subject: Psychology

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Approved by:

Chair of Committee,	Eddie Harmon-Jones
Committee Members,	Gerianne Alexander
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ABSTRACT

Approach- and Withdrawal-Oriented Responses to Social Rejection: The Role of Asymmetrical Frontal Cortical Activity. (December 2009)

Carly Kathryn Peterson, B.A., University of Wisconsin – Madison

Chair of Advisory Committee: Dr. Eddie Harmon-Jones

Ostracism arouses negative affect. However, little is known about variables that influence the intensity of these negative affective responses. Two studies seek to fill this void by incorporating work on approach- and withdrawal-related emotional states and their associated cortical activations. Study 1 found that following ostracism, anger related directly to relative left frontal cortical activation. Study 2 used unilateral hand contractions to manipulate frontal cortical activity prior to an ostracizing event. Right-hand contractions, compared to left-hand contractions, caused greater relative left frontal cortical activation during the hand contractions as well as during ostracism. Also, right-hand contractions caused more self-reported anger in response to being ostracized. Within-condition correlations revealed patterns of associations between ostracism-induced frontal asymmetry and emotive responses to ostracism consistent with Study 1. Taken together, these results suggest that asymmetrical frontal cortical activity affects angry responses to ostracism, with greater relative left frontal cortical activity being associated with increased anger.

NOMENCLATURE

EEG	Electroencephalography
EMG	Electromyography

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1. INTRODUCTION

We often learn much about the power of psychological variables to influence important outcomes when we strip the variables down to minimal manipulations (Prentice & Miller, 1992). Attesting to the pervasiveness of our liking for our own groups, the minimal group paradigm revealed that simply assigning individuals to groups on the bias of random criteria causes individuals to evaluate their own group more positively (Tajfel, Billig, Bundy, & Flament, 1971). Attesting to the ease with which we can learn to like things, the mere exposure paradigm revealed that simply repeatedly presenting individuals with unreinforced stimuli causes them to like those stimuli more (Zajonc, 1968). More recently, the Cyberball paradigm has revealed that individuals will feel negative emotions when ostracized from a group (Williams, 2007a), even when they know the group is fictitious (Zadro, Williams, & Richardson, 2004). These results suggest that individuals easily bond with others and feel powerful negative feelings when left out.

We might imagine, based on our own experiences, that there are reliable individual differences in how bad individuals feel when ostracized. However, we would be wrong: Research has been unable to find reliable predictors of the degree of negative affect individuals feel when ostracized (Williams, 2007a). The present studies sought to address this issue by taking a social neuroscience approach.

Ostracism causes negative affect. In this area of research, negative affect usually

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This thesis follows the style of *Psychophysiology.*

describes both anger and sadness, which have been shown to increase as a result of ostracism (Williams, 2007b). Williams (2007a) even refers to these distinct emotions collectively as “distress.” This ostracism-induced negative affect link has been shown to be unaffected by a number of situational and individual difference variables (see Williams, 2007a). However, the understanding of variables that influence the intensity of negative affective responses to ostracism is important for predicting emotional consequences of ostracism.

Subjective emotional responses associated with approach vs. withdrawal motivation are influenced by asymmetric frontal cortical activity (Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Harmon-Jones, 2003). Relative left frontal cortical activity relates to approach-oriented emotions such as anger (e.g., Harmon-Jones & Sigleman, 2001; van Honk & Schutter, 2006; Verona, Sadeh, & Curtin, 2009) and desire (Harmon-Jones & Gable, 2009), whereas relative right frontal cortical activity relates to withdrawal-oriented emotions such as sadness (Jacobs & Snyder, 1996; Jones & Fox, 1992; Schmidt & Trainor, 2001), fear, and disgust (Coan, Allen, & Harmon-Jones, 2001).

Study 1 was designed to test whether the pattern of asymmetric frontal cortical activity to ostracism would assist in predicting the degree and type of negative emotional experience ostracism evokes. Based on past research on frontal asymmetry and emotions, I would predict that anger should be associated with greater relative left frontal activation. Such a prediction would lead us to expect no differences between ostracism and inclusion in asymmetrical frontal cortical activity. Support for this prediction would benefit understanding of reflexive responses to ostracism by providing a pattern of neural activation that predicts the extent to which an individual feels negative emotions to being ostracized.

In Study 2, frontal asymmetry was manipulated via unilateral hand contractions. This manipulation was predicated on past research that suggested that unilateral hand contractions activate the contralateral motor cortex and these motor cortex activations spread to the dorsolateral prefrontal cortex and prime approach or withdrawal motivational processes (Harmon-Jones, 2006; Peterson, Shackman, & Harmon-Jones, 2008; Schiff & Lamon, 1994; Schiff, Guirguis, Kenwood, & Herman, 1998). Based on this past research, it was predicted that in Study 2, unilateral hand contractions would show the same pattern of contralateral activation in the central, frontal-central, and frontal regions of the brain. Furthermore, right-hand contractions, compared to left-hand contractions, would cause an increase in self-reported anger immediately following the ostracism. Finally, I expect to find the same relationship between frontal cortical activity during ostracism and self-reported emotions, so that anger will be associated with increased left frontal cortical activity. Together, both studies aim to shed light on the emotional consequences of ostracism, specifically in terms of the effect of asymmetrical frontal cortical activity on the intensity and type of responses.

2. STUDY 1

2.1 METHOD

Forty (20 male) right-handed introductory psychology students participated in exchange for partial course credit. Instructions for Cyberball were presented on the computer monitor. All participants were instructed to practice their mental visualization skills during the game, and to pretend as if they were playing the game in real life. All participants were aware that the other players did not actually exist, as in Zadro et al. (2004). The game was programmed in one of two ways. In the ostracism condition, participants were included the first part of the game (approximately 8 throws) and then ostracized during the second half (approximately 16 throws). In the inclusion condition, participants were included during the entire game. Condition assignment was determined randomly. EEG was recorded during the task.

When the game was over (approximately four minutes later), participants completed a questionnaire assessing their perceived level of anger[1], enjoyment, and the four fundamental needs (Zadro et al., 2004). Responses were made on a 9-point scale (1 = not at all, 9 = very much so). A manipulation check was included to assess participants' perceived level of inclusion during the game (i.e. "What percent of the

[1] Two self-report anger measures were included. The first asked participants to rate their agreement with the statement: "I felt angry during the Cyberball game." The second was presented after this as part of a myriad possible emotions (anger words were anger, irritated, and mad; *Cronbach's alpha* = .89). The two anger measures were only marginally correlated and the second anger measure was not related to frontal asymmetry. It is possible that the second anger measure was less sensitive because of its placement behind the first anger measure.

throws were thrown to you? Circle your best guess" with possible answers ranging from 0 – 100% in 10% intervals). In this study, they also reported their sadness (sad, gloomy, down, discouraged; *Cronbach's alpha* = .78), distress (distress, disgust, afraid, nervous; *Cronbach's alpha* = .64), and positive affect (happy, good mood, satisfied, glad, content, eager, excited, interested; *Cronbach's alpha* = .88). All responses were made on 9-point scales (1 = not at all, 9 = very much so).

EEG, re-referenced globally to the whole head, was recorded from 59 tin electrodes mounted in a stretch-lycra electrode cap (Electro-Cap International, Eaton, OH). Impedances were under 5,000 ohms; homologous sites were within 1,000 ohms of each other. Signals were amplified (60-Hz notch filter), bandpass filtered (0.05–100 Hz), and digitized at 500 Hz. Signals were manually scored for artifacts. Then, a regression-based eye movement correction was applied (Semlitsch, Anderer, Schuster, & Presslich, 1986). All 1.02-s epochs were extracted through a Hamming window. A fast Fourier transform extracted power within the alpha band (8–13 Hz), although power within both low alpha (8-10.25 Hz) and upper alpha (10.25–12.50 Hz) bands was examined. Preliminary analyses revealed that effects were found in the upper alpha band, and thus statistical analyses focus there. Power was averaged across epochs during the two parts of the game.

Asymmetry indices were created for homologous sites (natural log right minus natural log left). Because alpha power is inversely related to cortical activity, higher scores indicate greater left than right activity (Davidson et al., 2000). Additional variables were created by subtracting the asymmetry index from the first half of the game from the asymmetry index from the second half of the game. Higher scores indicated greater relative frontal activity during the second half of the game. Due to my interest in asymmetrical frontal cortical activity, a mid-frontal (F1/2, F3/4), lateral frontal (F5/6, F7/8), and frontal central (FC1/2, FC3/4, and FC5/6) asymmetry index was created by combining the two mid-frontal electrodes, the two lateral frontal electrodes, and the three frontal central electrodes. Degrees of freedom differ for some analyses because some participants did not complete all self-report measures. Because predictions for all studies were directional, derived from theory, and specified in advance, they were evaluated using a one-tailed criterion of significance (Rosenthal, Rosnow, & Rubin, 2000).

2.2 RESULTS AND DISCUSSION

Regression analyses in which condition (included vs. ostracized, effect coded), frontal asymmetry, and their interaction predicted subjective anger response were used to test predictions. Mid-frontal asymmetry (F [1, 36] = 10.43, $p < .01$, *partial* $eta^2 = .22$), condition (F [1, 36] = 11.36, $p < .01$, *partial* $eta^2 = .24$), and their interaction (F [1, 36] = 13.39, $p < .001$, *partial* $eta^2 = .27$) predicted anger. To follow up the interaction, within-condition correlations between anger and mid-frontal asymmetry were examined. As predicted, within the ostracism condition, anger was significantly related to relatively greater left mid-frontal activation from the period of inclusion to the period of ostracism ($r = .62$, $p < .01$). See Figure 1. Within the inclusion condition, anger did not relate to asymmetrical mid-frontal activation ($r < -.14$, $p > .56$).

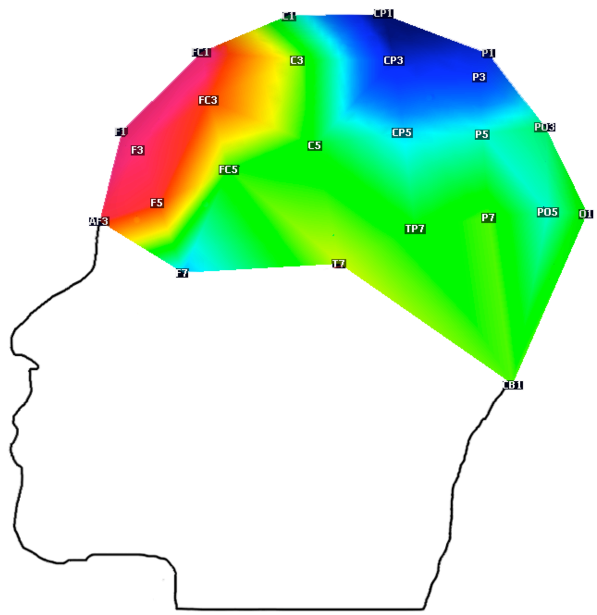

Figure 1. Topographic map displaying correlations between relative left hemispheric activation during ostracism and anger in Study 1. The display is a left lateral head view. Areas in hot pink correlated directly with anger.

Similar effects emerged for frontal-central asymmetry. That is, frontal-central asymmetry (F [1, 36] = 8.13, $p < .01$, *partial* $eta^2 = .20$), condition (F [1, 36] = 9.09, $p < .01$, *partial* $eta^2 = .18$), and their interaction (marginally) predicted anger (F [1, 36] = 3.40, $p = .07$, *partial* $eta^2 = .07$). Within the ostracism condition, anger was significantly related to greater left frontal-central activation ($r = .50$, $p < .05$). Within the inclusion condition, anger did not relate to left frontal-central activation, $r < .26$, $p > .27$. No other cortical asymmetries interacted with condition to predict anger.[1]

The same type of interaction regression analyses were performed for self-reported sadness, distress, meaningful existence, control, enjoyment, positive mood, self-esteem, and belonging. Only control produced a significant interaction with mid-frontal (F [1, 36] = 7.57, $p < .01$, *partial* $eta^2 = .17$) and frontal-central (F [1, 36] = 8.08, $p <$

.01, *partial* eta^2 = .18) asymmetries. Within-condition correlations revealed that during ostracism, control correlated inversely with mid-frontal (r = -.39, p = .09) and frontal-central (r = -.53, $p < .05$) asymmetries, but during inclusion, control correlated directly with mid-frontal asymmetry (r = .53, $p < .05$).

Replicating past research, as compared to participants who were included, participants who were ostracized reported being included in a smaller percentage of throws, and they reported greater levels of anger and lower levels of positive mood, enjoyment, belonging, control, and meaningful existence. Participants who were ostracized also reported marginally greater levels of sadness compared to participants who were included. There were no significant condition differences in self-esteem, distress, or frontal cortical asymmetries. See Table 1.

Table 1 Between-condition means (SDs) of variables in Study 1

	Condition		*t*
	Inclusion	Ostracism	
Percent Included	44.5 (10.50)	23.0 (9.23)	***6.88
Included	6.26 (1.15)	2.80 (1.20)	***9.22
Belonging	5.93 (0.98)	3.02 (1.47)	***7.38
Control	5.58 (1.58)	2.80 (1.18)	***6.31
Self-esteem	1.42 (1.17)	1.15 (1.06)	0.76
Meaningful Existence	6.78 (1.87)	3.85 (1.69)	***5.20
Enjoyment	4.60 (2.68)	2.10 (1.25)	***3.78
Anger	1.75 (1.16)	3.30 (2.11)	**2.88
Sadness	1.56 (0.76)	2.05 (0.98)	*1.65
Distress	1.53 (0.71)	1.71 (0.65)	0.80
Positive Mood	3.82 (1.14)	2.85 (0.94)	***2.64
Mid-Frontal Asymm	-0.03 (0.33)	0.00 (0.17)	0.39
Lat-Frontal Asymm	-0.04 (0.34)	-0.04 (0.26)	0.04
Frontal-central Asymm	-0.01 (0.35)	0.01 (0.27)	0.26

***$p < .01$; **$p < .05$; *$p < .06$.

To my knowledge, this is the first demonstration of a neural correlate of the effect of ostracism on experienced emotions. Importantly, the results of Study 1 suggest that reflexive emotional responses to ostracism can involve anger, and the degree of anger depends critically on the degree of relative left cortical activation aroused by ostracism. Study 2 extends the correlational results of Study 1 by examining whether physiological and emotional consequences of ostracism, specifically anger, are affected by manipulating frontal asymmetry with unilateral hand contractions.

3. STUDY 2

3.1 METHOD

Fifty (20 male) right-handed introductory psychology students participated in exchange for partial course credit. Following earlier suggestions (e.g., Basso, Schefft, & Hoffmann, 1994; Davidson et al., 1990; Levenson, 2003; Peterson, Shackman, & Harmon-Jones., 2008; Stemmler, 2003), I excluded participants who failed to show an asymmetric effect of the unilateral contraction manipulation on contralateral motor strip; data from 22 participants who failed to show greater relative left (right) activation in contralateral central electrodes (average of C3/4 and C5/6) during unilateral right (left) contractions were discarded. Two participants were then removed from analyses due to suspicion, leaving 26 participants (right hand: $n = 12$; left hand: $n = 14$) for hypothesis testing.

Participants were brought to the lab under the guise that they were participating in an experiment examining how personality, brain activity, and muscular system interact to affect cognitive performance during a task with other ostensible participants in the laboratory. Participants were told that the other individuals were asked to wait in another location in order to avoid coming into contact with him or her before the experiment began. After obtaining consent, the experimenter asked the participant to step out into the hall so a photograph could be taken of the participant. They explained that it would be used later in the experiment; no other instructions were given. Then, EEG and EMG were attached.

Following EEG and EMG attachments (described in detail later), four minutes (2-min eyes open, 2-min eyes closed) of resting, baseline activity was recorded. At this point in the experiment, face-to-face contact with the participant ceased and all instructions were given via envelope, computer, or intercom. Next, participants were instructed to squeeze a ball as hard as they could with their right or left hand while the opposite hand remained flat with the palm facing down. Hand contraction assignment was determined randomly and experimenters were blind to condition. Four 45-s contraction trials occurred with a 15-s relaxation period between each trial. The same procedure was used in Harmon-Jones (2006), Peterson, Shackman, and Harmon-Jones (2008), and Schiff et al. (1998). EEG and forearm EMG were recorded during contractions.

In the current study, the participant was told that they were playing Cyberball against two other participants. To bolster the story that the other players are real, photographs of real individuals (gender matched) were shown next to each cartoon player. In this version, all participants were in the ostracism condition. All other instructions and procedures for the game and post-game questionnaires were identical to Study 1.

Forearm EMG was recorded by placing tin electrodes (Electro-Cap International, Eaton, OH) on each forearm flexor. One electrode was placed one-third of the distance from the medial epicondyle of humerus to the styloid process of radius. The other electrode was placed 5 cm from the first electrode along the same line. Impedance levels were 10,000 Ohms or below.

EMG signals were amplified (an analog 60-Hz notch filter was enabled) with Neuroscan Synamps (El Paso, TX), bandpass filtered (0.05–500 Hz), and digitized at 2000 Hz. The signals were visually scored, and portions of the data that contained artifacts were removed. All epochs 1.024 s in duration were extracted through a Hamming window. A fast Fourier transform was used to calculate the power spectra, which was averaged across each period of the hand contractions. Total power within 70-100 Hz was obtained. Values were then log transformed to normalize across participants. All procedures for acquiring and processing EEG data were identical to those used in Study 1.

3.2 RESULTS AND DISCUSSION

EMG activity in the right and left forearms was measured during hand contractions to ensure that participants were indeed squeezing the ball as instructed. Data from two participants, both in the left hand condition, were lost due to equipment failure. Of the remaining 24 participants, all showed the predicted EMG asymmetry. Furthermore, a 2 (hand contraction: right, left) x 2 (forearm: right, left) ANOVA revealed that the hand contractions differentially affected EMG activity in the forearms, $F(1,22) = 445.85$, $p < .001$. Further analyses confirmed that greater EMG activity was found in the right forearm during right-hand contractions ($M = 4.09$, $SD = 1.16$) compared to left-hand contractions ($M = -1.74$, $SD = 1.05$), $t(22) = 12.89$, $p < .001$, whereas greater EMG activity was found in the left forearm during left-hand contractions ($M = 3.68$, $SD = 0.81$) compared to right-hand contractions ($M = -2.15$, $SD = 1.00$), $t(22) = 15.69$, $p < .001$. As expected, greater relative EMG activity in the right forearm compared to left forearm during contractions related to greater relative left lateral-frontal ($r = .40$, $p < .05$) and frontal-central ($r = .34$, $p < .06$) activation during the hand contractions.

As predicted, there was a significant effect of hand contraction on lateral frontal ($t[24] = 2.39$, $p < .05$) and frontal-central ($t[24] = 1.92$, $p < .05$) activation during the contractions. Participants who made right-hand contractions evidenced greater relative left lateral frontal activation ($M = 0.15$, $SD = 0.19$) and frontal central activation ($M = 0.12$, $SD = 0.25$) than those who made left-hand contractions ($M = -0.07$, $SD = 0.26$ and

M = -0.10, *SD* = 0.32, respectively). Hand contraction condition did not affect mid-frontal asymmetry, $t < 0.93$.

Change in frontal EEG asymmetry from the period of inclusion to the period of ostracism was next examined. Consistent with predictions, relative left lateral frontal activation was greatest for right-hand contractions (*M* = 0.05, *SD* = 0.31) compared to left-hand contractions (*M* = -0.29, *SD* = 0.52), $t(24) = 1.95$, $p < .05$. Relative left mid-frontal and frontal-central activation did not differ between right-hand (*M* = -0.05, *SD* = 0.30 and *M* = -0.05, *SD* = 0.39, respectively) and left-hand contractions (*M* = -0.20, *SD* = 0.42 and *M* = -0.07, *SD* = 0.58), *t*s < 0.97.

Consistent with predictions, self-reported anger in response to the Cyberball game was significantly greater after right-hand contractions (*M* = 4.17, *SD* = 2.62) compared to left-hand contractions (*M* = 2.43, *SD* = 1.70), $t(24) = 2.04$, $p < .05$. All other effects were not significant (*t*s < 1.66).

Within the right-hand condition, ostracism-induced anger was associated with greater relative left lateral frontal ($r = .50$, $p < .05$) and frontal-central ($r = .50$, $p < .05$) activation. See Figure 2. Within the left-hand contraction condition, ostracism-induced sadness was associated with greater relative right frontal central activation ($r = .52$, $p < .05$). Ostracism-induced distress also related to greater relative right mid-frontal ($r = .49$, $p < .05$) and frontal central ($r = .60$, $p < .05$) activation.

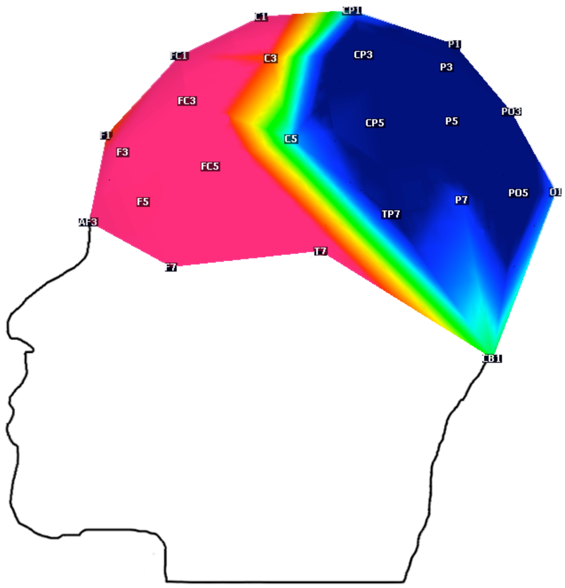

Figure 2. Topographic map displaying correlations between relative left hemispheric activation during ostracism and anger within the right-hand contraction condition in Study 2. The display is a left lateral head view. Areas in hot pink correlated directly with anger.

Study 2 extended Study 1 by showing that hand contraction condition differentially affected both physiological and emotive responses to ostracism. Right-hand contractions, relative to left-hand contractions, caused increased frontal cortical activity (during the contractions and during ostracism) and increased self-reported anger. Furthermore, within-condition correlations replicated Study 1 in that left frontal activation related directly to anger within the right-hand condition. Adding to Study 1, Study 2 also showed that, within the left-hand condition, relative right frontal activation related to sadness and distress.

4. GENERAL CONCLUSIONS

Study 1 found that ostracism-induced anger is directly correlated with increased relative left frontal activity. Supporting these findings, Study 2 demonstrated that right-hand, as compared to left-hand, contractions caused greater relative left frontal cortical activation during the hand contractions as well as during ostracism, and caused greater self-reported anger in response to ostracism. Furthermore, within-condition correlations revealed patterns of associations between frontal activation and angry responses to ostracism consistent with Study 1.

Only subjective anger was affected by the ostracism manipulation of Study 1 and the hand contraction manipulation of Study 2. Sadness and distress were not affected by these manipulations. However, in Study 2, relative right frontal activation related directly to sadness and distress, only within the left-hand contraction condition. Study 1 did not reveal similar correlations when hemispheric dominance was not manipulated. Perhaps the manipulated increase in relative right frontal activation is necessary to cause the association of relative right frontal activation and sadness/distress to ostracism. It may also be possible that these relationships may not have been evident in Study 1 due to restricted variance. That is, the left-hand condition of Study 2 demonstrated larger standard deviations in frontal asymmetry than the right-hand condition of Study 2 and both conditions of Study 1. The left-hand contractions apparently "freed" up additional relative right-frontal variance, making that variable more able to correlate with sadness and distress in Study 2.

Together with past experiments showing that right- compared to left-hand contractions increase greater relative left frontal activity (Harmon-Jones, 2006; Peterson, Shackman, & Harmon-Jones, 2008), these results suggest that manipulations of relative left frontal activation increase subjective anger to ostracism. Such results are consistent with the motivational direction model of asymmetrical frontal cortical activity (Harmon-Jones, 2003).

This research illustrates the importance of examining distinct negative affects rather than clustering all negative affects into one index, which has been encouraged by factor analytic studies that suggest that all negative affects load on one factor. Recent research has revealed that one of the most often used measures of negative affect splits into distinct factors of anger vs. fear/distress when individuals are actually experiencing strong bouts of affect caused by distinct emotion manipulations (Harmon-Jones, Harmon-Jones, Peterson, & Abramson, 2009) as opposed to how they felt over long periods of time (Watson, 2000).

The current results aid in understanding the “reflexive” responses to ostracism noted by Williams (2007a) and suggest some interesting avenues for further research on individual difference moderators of such responses to ostracism. Past research has suggested that ostracism-induced negative affect emerges regardless of several individual differences (see Williams, 2007a, for a review). Perhaps neural measures, like EEG, provide more direct assessments of approach and withdrawal motivation that may relate better to reflexive emotion responses such as anger than other measures used in past research.

In the end, this work illustrates two benefits of a social neuroscience approach (Adolphs, 2003; Harmon-Jones & Devine, 2003): it generated a novel hypothesis derived from a neuroscience approach that shed light on a problem in social psychological research on ostracism, and it used social psychological methods to further our understanding of the role of a pattern of neural activation in psychological processes.

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