An fMRI investigation of empathy for 'social pain' and subsequent prosocial behavior

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A B S T R A C T

Despite empathy's importance for promoting social interactions, neuroimaging research has largely overlooked empathy during social experiences. Here, we examined neural activity during empathy for social exclusion and assessed how empathy-related neural processes might relate to subsequent prosocial behavior toward the excluded victim. During an fMRI scan, participants observed one person being excluded by two others, and afterwards sent emails to each of these 'people.' Later, a group of raters assessed how prosocial (e.g., helpful, comforting) the emails were. Observing exclusion (vs. inclusion) activated regions associated with mentalizing (dorsomedial prefrontal cortex, medial prefrontal cortex, precuneus), and highly empathic individuals activated both mentalizing regions and social pain-related regions (anterior insula, dorsal anterior cingulate cortex). Additionally, the empathy-related activity in the anterior insula and medial prefrontal cortex was associated with later prosocial behavior toward the victim, and exploratory mediation analyses indicated that medial prefrontal cortex activity, in particular, may support the link between trait empathy and prosocial behavior. Overall, findings suggest that empathy-related neural responses to social experiences may promote spontaneous prosocial treatment of those in need.

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Empathy is considered to be a foundation of human social experience. It allows us to understand others' feelings, even when they are different from our own, and facilitates prosocial interaction. In fact, decades of social psychological research on empathy has emphasized empathy's role as a catalyst for prosocial behavior. For example, feeling more empathy is associated with greater concern for others' welfare (Batson, 1998) and more helping behavior (Batson, 1991, 1998; Dovidio et al., 1990; Schroeder et al., 1988; Oswald, 1996; Davis, 1983; Davis et al., 1999). Surprisingly, however, neuroimaging research on empathy has not examined empathy for others' social experiences or the neural processes through which this empathy for others' social experiences results in spontaneous prosocial actions. In fact, most of the research on empathy has focused on empathy for physical pain rather than empathy for negative social experiences (although see Immordino-Yang et al., 2009), even though observing negative social experiences is likely to be a more frequent occurrence. Here, we used functional magnetic resonance (fMRI) to identify neural regions involved in empathy for a negative social experience—social exclusion—and explored how neural activity in these regions related to individuals' subsequent prosocial behavior toward the victim of this exclusion.

Behavioral research has suggested that empathy includes two primary components (Davis, 1983): (1) an affective component that involves sharing the emotional experiences of others, and (2) a cognitive component that involves thinking about and understanding the mental states of others ('mentalizing'; Frith et al., 1991). Unfortunately, with behavioral measures alone, it has been difficult to differentiate between these two components of empathy or to examine how each of these components might be involved in social interactions or relate to empathy-induced prosocial behavior.

Fortunately, recent neuroimaging research has begun to disentangle the affective and cognitive components of empathy by showing that each relies on distinct neural networks (Decety and Meyer, 2008; Singer, 2006; Shamay-Tsoory et al., 2009). Specifically, the affective component of empathy relies on limbic regions that are activated during direct affective experiences such as fear, disgust, and physical pain. For example, the dorsal anterior cingulate cortex (dACC) and anterior insula are activated both during the direct experience of physical pain and while watching another in pain (Singer et al., 2004; Jackson et al., 2005; Botvinick et al., 2005). In contrast, the cognitive component of empathy relies on a network of regions associated with 'mentalizing,' the process of thinking about the contents of other people's minds, and includes the ventromedial, medial and dorsomedial prefrontal cortices (VMPFC; MPFC; DMPFC), the posterior superior temporal sulcus (pSTS), the temporal poles, the posterior cingulate cortex (PCC), and the precuneus (Frith and Frith, 1999, 2003, 2006, Beer and Hughes, 2010; Mitchell et al., 2005; Singer, 2006; Hynes et al., 2006).

To date, most fMRI research examining empathy has focused on empathy for physical pain, rather than empathy for social experiences.

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Thus, it is important to extend this work by examining which neural systems underlie empathy for negative social experiences. Moreover, given the importance of empathy for facilitating prosocial behavior, it is important to explore which neural components of empathy (affective vs. cognitive) are most critical for facilitating prosocial behavior toward the target of the empathy. While two recent studies have examined neural correlates of prosocial behavior, these have focused on associations between various prosocial proclivities and empathy for physical pain (Hein et al., 2010) or general emotional pain (Mathur et al., 2010), rather than on empathy for social experiences in particular and the prosocial actions that occur spontaneously as a result of witnessing these social experiences. To address these issues, we examined: (a) the neural processes involved in empathy for a negative social experience (social exclusion); (b) which of these specific neural networks underlying empathy for social exclusion related to individuals' spontaneous prosocial behaviors toward the victim of the exclusion subsequently; and (c) whether activity in these empathy-related neural regions might explain some of the association between empathy and prosocial behavior toward the victim.

In this study, participants were scanned while they observed three supposed people playing an online ball-tossing game from which one player was eventually excluded. First, we assessed neural activity while participants observed social exclusion compared to inclusion and explored how activity in these regions correlated with trait empathy. Based on previous work showing that the same regions are involved in both direct and observed experiences of physical pain (dACC, anterior insula; Singer et al., 2004, 2006), we expected that regions associated with the distressing experience of social exclusion (dACC, anterior insula; Eisenberger et al., 2003, 2007a,b; DeWall et al., 2010; Way et al., 2009) would also be activated during empathy for social exclusion. In addition, we also expected that empathy for social exclusion would engage neural regions supporting mentalizing processes (e.g., DMPFC). Although these regions have not been consistently implicated in studies examining empathy for physical pain to the same degree as the dACC and anterior insula (i.e., affective/pain regions), we expected that empathizing with another's negative *social* experience might require mentalizing processes, such as perspective taking, in order to understand the heightened complexity and ambiguity of social situations, and why incidences of negative treatment might be occurring.

Next, we examined which of these empathy-related neural activations was associated with a tendency for subjects to display spontaneous prosocial behavior toward the excluded victim. Again, given the potential importance of mentalizing as well as affective processes, for deciding how to interact with others, we expected that regions involved in mentalizing during an empathic experience, in addition to those involved in pain-related processing, might relate to subsequent prosocial actions toward the victim.

Finally, we performed exploratory mediation analyses to assess whether any of these empathy-related neural activations might explain some of the relationship between trait empathy and prosocial behavior toward the victim. Given previous work showing that perceived self–other overlap mediates the relationship between empathic concern and helping behavior (Cialdini et al., 1997), we expected that regions that have been shown in prior research to be involved in perceiving others as similar to oneself (i.e., MPFC; Mitchell et al., 2006) might potentially contribute to the mechanistic processes linking empathy with prosocial behavior toward those in need.

Method

Participants

Participants included 18 individuals (nine females; $M = 20.22$ years old, range: 18–24) recruited from undergraduate classes. Participants were 72% Caucasian and 28% Asian American. All participants provided written consent in accordance with the university's institutional review board. Two participants reported that they had been suspicious about the study's purpose as they were being scanned. Since they were not outliers on any of the self-report measures, they were excluded from neuroimaging analyses only. Thus, there were 16 participants included in neuroimaging analyses (nine females; $M = 19.88$ years old).

Procedure

Participants were scanned while they observed another supposed person being excluded during a computerized ball-tossing game ("Cyberball"; Williams et al., 2000, 2002). They were told that the study's purpose was to examine neural activity during observed social interactions and that three previous participants had volunteered to play the game via the internet during the scan. Participants were given the first names and genders of these 'previous participants' (one male, one female, and the gender of the excluded player that matched that of the participant), and were instructed to watch closely and think about what the players might be thinking or feeling, how they were treating each other, and what strategies they were using to decide the recipient of each ball toss. Extensive measures were taken throughout the study to maintain the believability of the cover story (e.g., between runs, participants were asked to wait for a short time while one of the 'players' used the restroom). Participants observed two rounds of Cyberball: one in which everyone was included equally in the game (60 throws total), and a second during which one player was excluded for the entire round after being included for only 10 throws. This paradigm has been used successfully in previous behavioral and neuroimaging studies to simulate social exclusion and produce distress (Eisenberger et al., 2003, 2007a,b; DeWall et al., 2010; Masten et al., 2010a; van Beest and Williams, 2006; Zadro et al., 2004).

Following completion of the fMRI scan, participants completed a manipulation check to ensure that they had noticed the exclusion of one player and felt some degree of state empathy as a result. Then, they emailed messages to all of the players that they observed. The emails were later scored for how prosocial they were by a group of raters, and ratings of emails to the victim were compared to ratings of emails to the other players. Additionally, participants self-reported their trait empathy (see details of these measures below). After completing all measures, participants were fully debriefed about the deception involved in the study.

Behavioral measures

Manipulation check

Following the scan, experimenters asked participants whether specific events had happened during the game that they observed (e.g., "*one player was treated unfairly,*" "*all the players participated in the game the same amount*"). Results indicated that all participants had noticed the exclusion. Participants also indicated the amount of state empathy they felt while watching the exclusion round by reporting their feelings for the excluded player using a 5-point scale (1 = not at all to 5 = very much so). This measure included 10 items, such as "*I felt bad for him/her,*" and "*It hurt to watch him/her play,*" and was highly reliable ($\alpha = .92$),

Emails to Cyberball players

Next, participants were told that they could email the players that they observed, since they did not meet them in person. To maintain ecological validity, real email accounts were created for each participant and all three Cyberball 'players.' Participants were instructed to write whatever they wanted about what they had observed (but were not explicitly told to mention the exclusion) and

sent the emails when they finished. Following the final study debriefing, experimenters obtained participants' permission to use these emails.

Prosocial ratings of emails

Eighteen raters who did not interact with the study participants completed questionnaires designed to assess how 'prosocial' the participants' emails were to the victim and non-victims. Prosocial behavior is generally defined as constituting actions that are helpful to others (e.g., helping, sharing, comforting, rescuing; Batson, 1998; Dovidio et al., 2006), and here we specifically focused on a subset of prosocial behaviors that were: (a) directed toward the observed victim (as opposed to people more generally—as in the case of charitable donation), (b) relevant to the specific context of social exclusion, and (c) realistic in the context of email. Thus, we specifically focused on how much participants tried to support, comfort, and help the excluded victims through their emails. Research has shown that social support and connection are desired following social exclusion (Maner et al., 2007), are effective in reducing responses to social exclusion and other aversive experiences (Cohen and Wills, 1985; Eisenberger et al., 2007b; Masten et al., 2010b), and facilitate recovery of self-esteem and feelings of acceptance following exclusion—even when they occur via the internet (Gross, 2009). To this end, raters answered three questions about each email: "*Does it seem like they are trying to comfort this person?*", "*How supportive are they toward this person?*", and "*How much do they seem like they are trying to help this person?*". Raters were asked to consider their 'general impression' and to answer each question using a 7-point scale (1 = not at all to 7 = very much). For each email, the ratings for the three questions were averaged across the raters, and a difference score was computed for each participant indicating how prosocial their email was to the excluded player, compared to the non-excluded players (ICC = .89). This difference score was used in order to specifically assess how much *more* prosocial participants were toward a person that they observed being treated unfairly, above and beyond their prosocial tendencies more generally (i.e., toward the people who were not excluded).

Trait empathy

Participants self-reported their trait empathy using the Empathy Index (Bryant, 1982),[1] which consists of 22 items assessing different aspects of perspective taking, empathic sadness, and concern for others (e.g., "It's hard for me to see why someone else gets upset," "Seeing a woman/man who is crying makes me feel like crying"). Participants indicated their agreement with each statement using a 9-point scale (1 = very strongly disagree to 9 = very strongly agree). Items were reverse coded appropriately and averaged to create one total composite score for trait empathy (α = .82).

fMRI data acquisition

Images were collected using a Siemens Trio 3-Tesla MRI scanner. First, a high-resolution structural scan (echo planar T2-weighted spin-echo, TR = 4000 ms, TE = 54 ms, matrix size 128 × 128, FOV = 20 cm, 36 slices, 1.56-mm in-plane resolution, 3-mm thick) coplanar with the functional scans was obtained for functional image registration during data preprocessing. Then, each round of Cyberball was completed during a functional scan lasting 168 s (echo planar T2*-weighted gradient-echo, TR = 2000 ms, TE = 25 ms, flip angle = 90°, matrix size 64 × 64, 36 axial slices, FOV = 20 cm; 3-mm thick, skip 1 mm).

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[1] Given that this sample of adult participants was collected as part of a larger study examining adolescent brain development, the Empathy Index was selected because of its relevance for developing populations (see Masten et al., 2010a). This scale was adapted slightly for an adult sample (e.g., references to "boys" were changed to "men").

fMRI data analysis

Neuroimaging data was preprocessed and analyzed using Statistical Parametric Mapping (SPM5; Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK). Preprocessing included image realignment to correct for head motion, normalization into a standard stereotactic space defined by the Montreal Neurological Institute and the International Consortium for Brain Mapping, and spatial smoothing using an 8-mm Gaussian kernel, full width at half maximum, to increase signal-to-noise ratio.

Modeling of contrasts

Cyberball was modeled as a block design. Observed inclusion comprised two blocks (the period of inclusion during round 1 and the period of inclusion immediately preceding exclusion during round 2), and observed exclusion comprised the exclusion block. Linear contrasts comparing observed exclusion to observed inclusion were calculated for each participant. These individual contrast images were then used in group level, whole-brain analyses.

Group level, whole-brain analyses

First, we performed a group level contrast comparing observed exclusion to observed inclusion. Next, we conducted a whole-brain regression analysis examining correlations between neural activity during observed exclusion vs. inclusion and self-reported trait empathy. All whole-brain analyses were thresholded at p<.005, 10 voxels, for a priori defined regions known to be involved in both mentalizing (e.g., DMPFC, MPFC, VMPFC, pSTS, PCC, and precuneus) and the affective component of empathy (e.g., dACC, anterior insula). This threshold is typical of studies examining a priori defined regions and comparable to a corrected threshold of p<.05 (Lieberman and Cunningham, 2009). All other brain regions were examined at a threshold corrected for multiple comparisons (corrected for family-wise error in SPM5; p<.05, 10-voxel minimum cluster size). All coordinates are reported in Montreal Neurological Institute (MNI) format.

ROI regression analyses

Next, we examined which empathy-related neural regions were related to subsequent prosocial behavior toward the victim. Each of the clusters that significantly related to trait empathy was defined as an ROI, and parameter estimates of the difference in activity during observed exclusion vs. inclusion across every voxel in each cluster were averaged to obtain the mean difference in activity for each ROI. This average difference in activity for each ROI was then entered as the independent variable into a regression model predicting the difference score in prosocial behavior toward the victim vs. the non-victims.

Exploratory mediation analyses

Finally, for each of these ROIs that significantly related to later prosocial behavior toward the victim, we performed an exploratory mediation analysis to examine whether empathy-related neural activity in the ROI might be involved in the link between trait empathy and prosocial behavior. Of course, in this investigation it was not possible to include a mediator (i.e., empathy-related neural activity) that was fully independent from the independent variable (i.e., trait empathy) given that the neural regions specifically involved in empathy for negative social experiences have not been previously identified in any other participant samples. Thus, we performed these exploratory tests simply as a means of assessing which neural regions might be important candidates for future examination of the processes via which empathy precipitates prosocial behavior. First, we used traditional methods of testing mediation, including Baron and Kenny's four-step approach to mediation (Baron and Kenny, 1986) and the Sobel test (Sobel, 1982), to examine whether the neural activity during empathy for social exclusion in each functionally defined ROI significantly mediated the relationship between trait
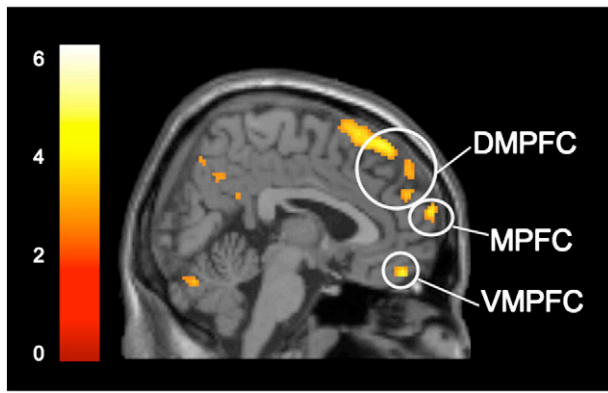
Fig. 1. Activity during observed exclusion vs. observed inclusion in the dorsomedial prefrontal cortex (DMPFC; 2 54 28), medial prefrontal cortex (MPFC; 4 68 18) and ventromedial prefrontal cortex (VMPFC; 2 50 −20).

empathy and prosocial behavior toward the victim. Then, given that these traditional methods can be biased when used with small samples (Preacher and Hayes, 2008), we also employed a boot-strapping method (scripted within SPSS; Preacher and Hayes, 2004) with bias-corrected confidence intervals to further interrogate the significance of these mediation effects (Preacher and Hayes, 2004; Shrout and Bolger, 2002). Bootstrap analyses and estimates are based on 2000 bootstrap samples.

Results

Behavioral results

Descriptive information

Participants reported feeling significant levels of state empathy (i.e., scores greater than 1) for the excluded player (range: 1.1–4.5; $M = 3.23$, $SD = .81$; $F = 11.40$, $p < .0001$), suggesting that they were engaging in empathic processes as they witnessed exclusion. Participants also displayed a range of trait empathy scores (range: 4.86–7.45; $M = 6.09$, $SD = .82$). Additionally, their prosocial behavior toward victims ($M = 4.46$, $SD = 1.35$; range: 1.80–6.50) and non-victims ($M = 2.03$, $SD = .50$; range: 1.15–3.00) differed significantly ($t = 7.94$, $p < .0001$). This difference score (i.e., prosocial behavior toward the victim *above and beyond* that displayed toward non-victims; 0.17–4.24, $M = 2.30$; $SD = 1.23$) was used in all analyses (subsequently referred to as 'prosocial behavior toward the victim').[2] Consistent with previous research, trait empathy was positively correlated with prosocial behavior toward the victim ($r = .50$, $p < .05$).

Qualitative results of emails

There was substantial variability in how prosocial participants' emails were to the victims of the exclusion. For example, the following email to the victim was rated the most prosocial (prosocial score = 6.50):

"Dear Adam, While watching your game of Cyberball I noticed you may have felt left out when Erika and Danny were consistently throwing the ball to each other. I just wanted to say I'm sorry that happened and I am sure there is some explanation that has nothing to do with you. You seemed to be a great ball thrower."

Whereas, the following email to the victim was rated the least prosocial (prosocial score = 1.80):

"Hey Anna, Thanks for participating in the game with the other two participants. It was an interesting game, and I hope that you had fun!"

In contrast, there was relatively little variability in prosocial ratings of the emails to the non-victims. The following is a typical example (prosocial score = 1.63):

"Hey Danny, Hope you had fun participating in the Cyberball game! Thanks for taking your time out to participate in this study!"

Neuroimaging results

Neural activity during observed exclusion vs. observed inclusion

A whole-brain contrast revealed that participants displayed greater activity in neural regions previously linked with mentalizing when they observed someone being excluded vs. included by others (Fig. 1). Specifically, there were two significant clusters of activity in the DMPFC as well as significant activity in the MPFC, VMPFC, and precuneus (Table 1). Thus, when observing another person's social interactions, individuals may utilize mentalizing processes more when they observe someone being excluded than when they observe a group of people treating each other equally. Interestingly, unlike previous studies of empathy for physical pain, there were no social pain-related neural activations in response to viewing another experiencing social pain.

Regions associated with trait empathy

Next a whole-brain regression analysis was performed in order to identify brain regions that correlated with individuals' empathic ability. This analysis revealed significant positive correlations between participants' self-reported trait empathy and activity during observed exclusion versus inclusion in several neural regions previously linked with mentalizing as well as social pain processing. First, greater trait empathy was associated with more activity in the DMPFC, MPFC, and PCC (Table 2), suggesting that individuals who report having greater empathic ability may also engage in more mentalizing. In addition, greater trait empathy was also associated with more activity in the bilateral anterior insula (Fig. 2a) and dACC (Fig. 2b; Table 2), suggesting that individuals who report being more empathic also display more social pain-related activity when observing another person being excluded. There were no negative correlations between self-reported trait empathy and activity during observed exclusion versus inclusion.[3]

Table 1
Regions activated during observed exclusion compared to observed inclusion.

Anatomical region	BA		x	y	z	t	k	p
DMPFC	9	R	2	54	28	4.01	384	<.0005
	8	R	8	36	58	5.49	625	<.0001
MPFC	10	R	4	68	18	4.40	384	<.0005
VMPFC	11	R	2	50	−20	5.22	131	<.0001
Precuneus	7	R	10	−78	60	3.84	28	<.001

Note. BA refers to putative Brodmann's Area; L and R refer to left and right hemispheres; x, y, and z refer to MNI coordinates in the left–right, anterior–posterior, and inferior–superior dimensions, respectively; t refers to the t-score at those coordinates (local maxima). The following abbreviations are used for the names of specific regions: dorsomedial prefrontal cortex (DMPFC), medial prefrontal cortex (MPFC), and ventromedial prefrontal cortex (VMPFC).

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[2] There were no meaningful differences in any of the behavioral or neuroimaging analyses if prosocial ratings of victim emails were used instead of the difference in prosocial ratings of victim vs. non-victim emails.

[3] Participants' feelings of empathy for the excluded player were collected primarily as part of the manipulation check to ensure that participants were engaging in empathic processes as they witnessed exclusion. However, whole-brain regressions indicated that these exclusion-related empathy ratings correlated with brain activity in ways similar to trait empathy. Specifically, individuals who felt more empathy for the excluded player displayed greater activity in regions previously linked with mentalizing (i.e., DMPFC [2 40 50], $t = 3.49$, $r = .68$, $p < .005$, $k = 40$, and [14 30 64], $t = 4.30$, $r = .75$, $p < .0005$, $k = 1129$; MPFC [10 50 26], $t = 5.23$, $r = .81$, $p < .0001$, $k = 85$; PCC/Precuneus [8 −60 50], $t = 5.39$, $r = .82$, $p < .0001$, $k = 821$), and social pain processing (i.e., dACC [16 24 50], $t = 3.35$, $r = .67$, $p < .005$, $k = 1129$).

Table 2
Regions activated during observed exclusion compared observed inclusion that correlated significantly with trait empathy scores.

Anatomical region	BA		x	y	z	t	r	k	p
Positive associations with trait empathy									
Anterior insula		R	42	20	−6	4.76	.86	825	<.0005
		L	−46	18	-8	6.22	.83	675	<.0001
dACC	24	L	−2	12	30	4.78	.74	105	<.0005
DMPFC	8	L	−2	30	58	5.36	.79	271	<.0001
MPFC	10	R	4	70	16	4.15	.90	63	<.0005
PCC	7		0	−50	46	3.74	.70	57	<.001

Note. BA refers to putative Brodmann's Area; L and R refer to left and right hemispheres; x, y, and z refer to MNI coordinates in the left–right, anterior–posterior, and inferior-superior dimensions, respectively; t refers to the t-score at those coordinates (local maxima); r refers to the correlation coefficient representing the strength of the association between trait empathy scores and the average difference between activity during observed exclusion and activity during observed inclusion across the entire cluster in each specified region. The following abbreviations are used for the names of specific regions: dorsal anterior cingulate cortex (dACC), dorsomedial prefrontal cortex (DMPFC), medial prefrontal cortex (MPFC), and posterior cingulate cortex (PCC).

Empathy-related neural activity associated with writing prosocial emails to victims

Next, we explored which empathy-related neural processes might contribute to individuals' subsequent efforts to act prosocially toward the victim. To do this, we first examined whether greater neural activity in the regions that were associated with trait empathy was associated with higher prosocial email scores to the victim. There were six regions of interest (ROI), in which activity during observed exclusion vs. inclusion correlated with trait empathy: MPFC, DMPFC, PCC, dACC, right anterior insula, and left anterior insula. Parameter estimates were extracted from each of these regions and regression analyses were run to see if neural activity in each ROI related to subsequent prosocial behavior toward the victim. Regression analyses revealed that neural activity in two ROIs related to subsequent prosocial email scores: the

MPFC ([4,70,16], β=.69, p<.005; Fig. 3a) and the right anterior insula ([42,30,−6], β=.60, p<.05; Fig. 3b). Thus, neural activity associated with empathy for social pain in each of these regions related to individuals' later prosocial behaviors toward the victim.

Exploratory mediation analyses

Finally, we examined whether the neural activity in either of these two ROIs (MPFC and right anterior insula) might serve as a potential mediator of the link between trait empathy and prosocial behavior toward the victim. First, we performed these exploratory mediation tests separately for each of these regions according to the four-step approach outlined by Baron and Kenny (1986). As reported above, trait empathy significantly related to prosocial behavior toward the victim (β=.51, p<.05 for the 16 participants included in neuroimaging analyses), fulfilling step 1, and trait empathy related to neural activity (MPFC: β=.90, p<.0005; right anterior insula: β=.86, p<.0005), fulfilling step 2. For step 3, we examined whether activity in the MPFC and right anterior insula significantly related to prosocial behavior toward the victim, after controlling for trait empathy. Activity in the MPFC was positively associated with prosocial behavior toward the victim after controlling for trait empathy (β=.52, p<.05), and the resulting relationship between trait empathy and prosocial behavior toward the victim became nonsignificant (β=−.25, ns) after controlling for MPFC activity (Sobel test=2.20, p<.05). Although this test was not fully independent, this finding provides preliminary evidence that empathy-related activity in the MPFC while observing social exclusion may partially explain the relationship between trait empathy and prosocial behavior toward the victim. In contrast, activity in the right anterior insula was not significantly associated with prosocial behavior after controlling for trait empathy (β=.31, ns) and failed the Sobel test (=1.20, ns). Of course, we cannot rule out the possibility that the right anterior insula would have a significant mediational effect in a larger (or independent) sample. However, in this particular investigation, the relationship
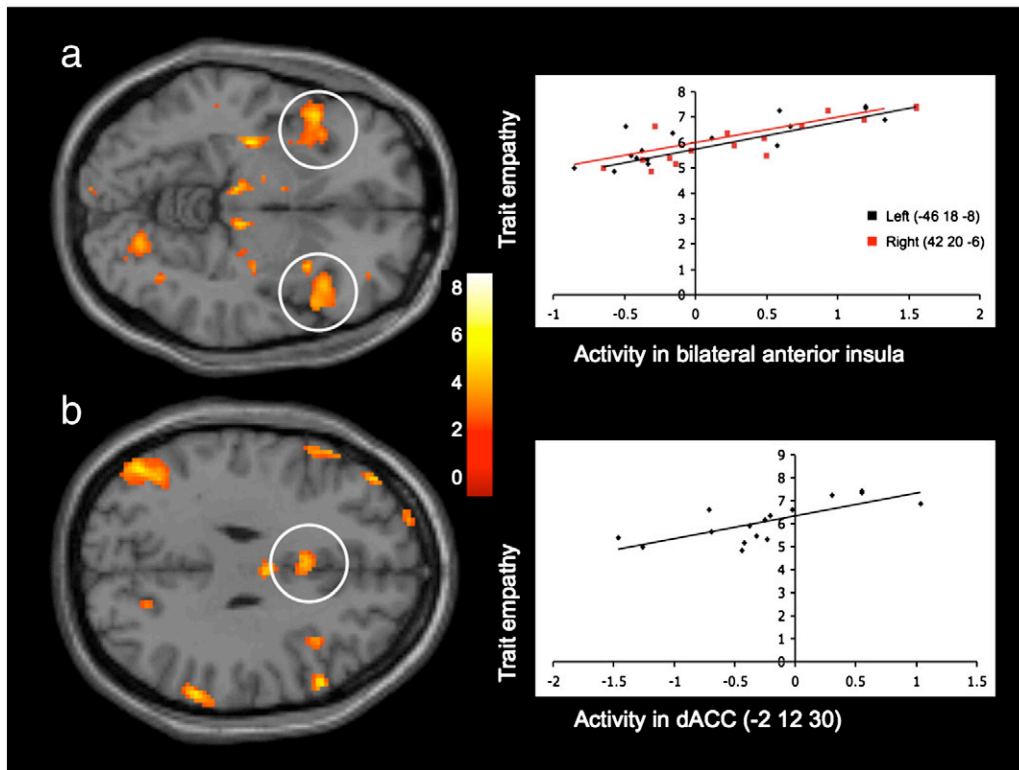

Fig. 2. Activity during observed exclusion vs. observed inclusion in the bilateral anterior insula (a) and dorsal anterior cingulate cortex (dACC) (b) that is positively related to participants' self-reported levels of trait empathy. Scatter plots are provided to illustrate the relationship between the average difference in activity (exclusion vs. inclusion) across each specified cluster and the ratings of trait empathy.
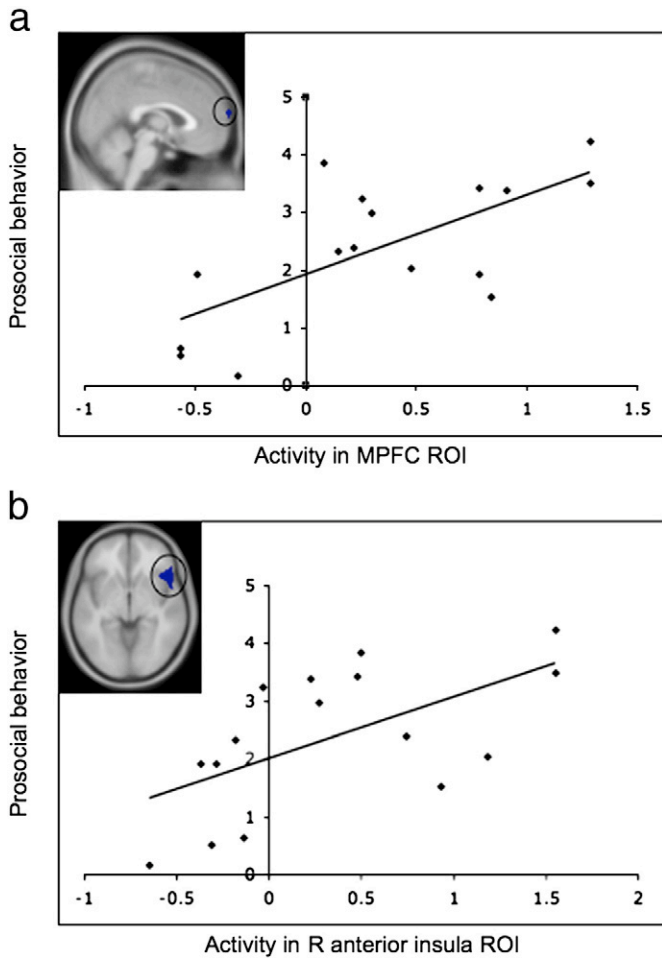
a

b

Fig. 3. Activity during observed exclusion vs. observed inclusion in the (a) MPFC and (b) right anterior insula ROIs (functionally defined as clusters that were positively associated with trait empathy) that is positively related to how prosocial participants' emails were toward excluded victims (vs. non-victims). Scatter plots are provided to illustrate the relationship between the average difference in activity (exclusion vs. inclusion) across each ROI and the difference in prosocial ratings of emails to victims compared to non-victims.

between MPFC activity and prosocial behavior toward the victim (controlling for trait empathy) was 68% larger than that for right anterior insula activity, and this potential mediating effect of MPFC remained significant after controlling for the potential mediating effect of the right anterior insula ($\beta = .56$, $p < .05$). Thus, compared to the anterior insula, the MPFC appears to be a more important mediator of the relationship between trait empathy and prosocial behavior in this sample.

Finally, we further examined these meditational effects using a bootstrapping method that takes into account the potential for bias in small sample sizes. Findings from these bootstrapping analyses were consistent with the findings derived from the more traditional meditational tests; the total indirect effect of trait empathy on prosocial behavior through the MPFC was significant (95% confidence interval: .37–2.64; $p < .01$), while the indirect effect through the right anterior insula was not (95% confidence interval: −.32 to 1.78; $p = .17$). Taken together, these meditational analyses suggest that MPFC activity during observed social experiences likely serves a particularly important role in linking trait empathy and prosocial behavior.

Discussion

This study examined empathy-related neural processing and resulting prosocial behavior during observed social exclusion—an

occurrence that is salient and frequent during daily social interactions. As such, the current findings have extended previous research in three ways: (a) by identifying the neural processes that are involved in empathy for *social* pain, rather than empathy for physical pain—a topic which has dominated most neuroimaging research on empathy; (b) by examining which of these neural processes involved in empathy for social exclusion relate to subsequent displays of spontaneous, prosocial behavior toward the observed victim; and (c) by revealing a potential neural mechanism that may contribute to the well-known link between empathy and prosocial behavior.

Our findings indicate that the neural regions supporting empathy for social pain may differ from those previously linked with empathy for physical pain (see Singer, 2006). Specifically, mentalizing regions were more active during observed social exclusion, while activity in both mentalizing (DMPFC, MPFC, PCC) and affective (anterior insula, dACC) regions was positively associated with trait empathy. Thus, while prior studies have consistently found activity in dACC and anterior insula during observed physical pain, only highly empathic participants showed activity in the dACC and anterior insula during observed social pain, suggesting there may be important differences between empathy for different types of experiences (Immordino-Yang et al., 2009; Mobbs et al., 2009). For example, responses to observed physical pain may trigger an automatic, affective response such that most individuals spontaneously feel distress when they see someone in physical pain. In contrast, observing social exclusion might require an additional layer of mentalizing to understand the situation and imagine the victim's affective responses, and thus, might only elicit pain-related neural activity among the most empathic individuals. Given that understanding social situations is complex and relatively ambiguous, simply watching someone experiencing social pain may not automatically elicit distress like observing physical pain.

In addition, this study also investigated which empathy-related neural regions related to subsequent prosocial behavior. Individuals who displayed more activity in the MPFC and anterior insula (in response to observing exclusion) subsequently chose to write more prosocial emails to the victims of the exclusion compared to the non-victims. This is consistent with previous research linking greater empathy with increased prosocial behavior toward those in need (e.g., Batson, 1991, 1998), and suggests that individuals who experience more empathy for others who are experiencing negative social treatment will make greater efforts to help and support the victims in these situations.

These findings are also consistent with previous neuroimaging research showing that greater anterior insula (Hein et al., 2010) and MPFC (Mathur et al., 2010) activity during observed pain relate to greater prosocial tendencies (i.e., experiencing physical pain in order to 'share the burden' of the victim, Hein et al., 2010; or being more financially generous, Mathur et al., 2010). Moreover, the current findings extend this work by showing that empathy-related neural activity relates to spontaneous prosocial behavior in response to situations that we are likely to encounter as a regular part of our daily lives. In other words, it is common to see people being treated negatively by others (i.e., being teased, excluded from a social event, discriminated against), and providing support and comfort is a frequently used method of helping these people. In contrast, seeing someone undergoing physical suffering and trying to help them may occur more rarely. Thus, the current findings suggest that both the anterior insula and the MPFC are important for understanding natural prosocial actions that result spontaneously in response to common, 'everyday' social interactions.

Exploratory meditational tests of these two regions indicated that the MPFC, in particular, might serve a mechanistic role in the link between empathic processes and prosocial behavior. In previous studies, the MPFC has been consistently linked with trait empathy (Rankin et al., 2006; Shamay-Tsoory et al., 2003, 2005; Singer et al., 2004), emotional perspective taking (Hynes et al., 2006), and acting

generously toward others (Mathur et al., 2010). However, it is also involved in mentalizing about others that are perceived as similar to oneself (Mitchell et al., 2006). Therefore, one possibility is that highly empathic individuals generally perceive others as more similar to themselves and thus more easily take others' perspectives. As a result, they may relate better to others during empathic experiences and be more willing to help and support these 'similar' others. Consistent with this, Cialdini et al. (1997) have suggested that the commonly observed link between empathy and prosocial behaviors may be explained by a greater perceived self–other overlap among empathic individuals, which leads to a greater desire to act prosocially. Thus, thinking about how observed others are similar to oneself may be one important aspect of empathic processes that promotes increases in prosocial behavior. Although future investigations using larger samples and independent mediational tests may reveal additional brain regions that are important in promoting prosocial behaviors following empathic experiences (e.g., anterior insula), our preliminary findings suggest that the MPFC may be one important link in this chain that is particularly deserving of further attention in future studies.

In summary, the current study provides an important first step toward understanding individuals' experiences of empathy for negative social treatment and why certain individuals make efforts to help and support the victims of these negative social encounters. Eventually, understanding the neural links between empathic experience and efforts to help those in need may help explain the adaptive role that empathy serves in promoting positive interactions with others.

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References

Baron, R.M., Kenny, D.A., 1986. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. J. Pers. Soc. Psychol. 51, 1173–1182.
Batson, C.D., 1998. Altruism and prosocial behavior. In: Gilbert, D.T., Fiske, S.T., Lindzey, G. (Eds.), The Handbook of Social Psychology, vols. 1 and 2. McGraw-Hill, New York, NY, pp. 282–316.
Batson, C.D., 1991. The altruism question: toward a social-psychological answer. Erlbaum, Hillsdale, NJ.
Beer, J.S., Hughes, B.L., 2010. Neural systems of social comparison and the "above-average" effect. Neuroimage 49, 2671–2679.
Botvinick, M., et al., 2005. Viewing facial expressions of pain engages cortical areas involved in the direct experience of pain. Neuroimage 25, 312–319.
Bryant, B., 1982. An index of empathy children and adolescents. Child Dev. 53, 413–425.
Cialdini, R.B., Brown, S.L., Lewis, B.P., Luce, C., Neuberg, S.L., 1997. Reinterpreting the empathy-altruism relationship: when one into one equals oneness. J. Pers. Soc. Psychol. 73, 481–494.
Cohen, S., Wills, T.A., 1985. Stress, social support, and the buffering hypothesis. Psychol. Bull. 98, 310–357.
Davis, M.H., 1983. Measuring individual differences in empathy: evidence for a multidimensional approach. J. Pers. Soc. Psychol. 44, 113–126.
Davis, M.H., Mitchell, K.V., Hall, J.A., Lothert, J., Snapp, T., Meyer, M., 1999. Empathy, expectations, and situational preferences: personality influences on the decision to participate in volunteer helping behaviors. J. Pers. 67, 469–503.
Decety, J., Meyer, M., 2008. From emotion resonance to empathic understanding: a social developmental neuroscience account. Dev. Psychopathol. 20, 1053–1080.
DeWall, C.N., MacDonald, G., Webster, G.D., Masten, C.L., Baumeister, R.F., Powell, C., Combs, D., Schurtz, D.R., Stillman, T.F., Tice, D.M., Eisenberger, N.I., 2010. Acetaminophen reduces social pain: behavioral and neural evidence. Psychol. Sci. 21, 931–937.
Dovidio, J.F., Allen, J.L., Schroeder, D.A., 1990. Specificity of empathy-induced helping: evidence for altruistic motivation. J. Pers. Soc. Psychol. 59, 249–260.
Dovidio, J.F., Piliavin, J.A., Schroeder, D.A., Penner, L., 2006. The social psychology of prosocial behavior. Erlbaum, Mahwah, NJ.
Eisenberger, N.I., Lieberman, M.D., Williams, K.D., 2003. Does rejection hurt? An fMRI study of social exclusion. Science 302, 290–292.

Eisenberger, N.I., Gable, S.L., Lieberman, M.D., 2007a. fMRI responses relate to differences in real-world social experience. Emotion 7, 745–754.
Eisenberger, N.I., Taylor, S.E., Gable, S.L., Hilmert, C.J., Lieberman, M.D., 2007b. Neural pathways link social support to attenuated neuroendocrine stress responses. Neuroimage 35, 1601–1612.
Frith, C.D., Frith, U., 1999. Interacting minds — a biological basis. Science 286, 1692–1695.
Frith, C.D., Frith, U., 2006. The neural basis of mentalizing. Neuron 50, 531–534.
Frith, U., Frith, C.D., 2003. Development and neurophysiology of mentalizing. Philos. Trans. R Soc. Biol. Sci. 358, 459–473.
Frith, U., Leslie, A.M., Morton, J., 1991. The cognitive basis of a biological disorder: autism. Trends Neurosci. 14, 433–438.
Gross, E., 2009. Logging on, bouncing back: an experimental investigation of online communication following social exclusion. Dev. Psychol. 45, 1787–1793.
Hein, G., Silani, G., Preuschoff, K., Batson, C.D., Singer, T., 2010. Neural responses to ingroup and outgroup members' suffering predict individual differences in costly helping. Neuron 68, 149–160.
Hynes, C.A., Baird, A.A., Grafton, S.T., 2006. Differential role of the orbital frontal lobe in emotional versus cognitive perspective-taking. Neuropsychologia 44, 374–383.
Immordino-Yang, M.H., McColl, A., Damasio, H., Damasio, A., 2009. Neural correlates of compassion. Proc. Natl Acad. Sci. 106, 8021–8026.
Jackson, P.L., Bruney, E., Meltzoff, A.N., Decety, J., 2005. How do we perceive the pain of others? A window into the neural processes involved in empathy. Neuroimage 24, 771–779.
Lieberman, M.D., Cunningham, W.A., 2009. Type I and Type II error concerns in fMRI research: re-balancing the scale. Soc. Cogn. Affect. Neurosci. 4, 423–428.
Maner, J.K., DeWall, C.N., Baumeister, R.F., Schaller, M., 2007. Does social exclusion motivate interpersonal reconnection? Resolving the "Porcupine Problem". J. Pers. Soc. Psychol. 92, 42–55.
Masten, C.L., Telzer, E.H., Eisenberger, N.I., 2010a. An fMRI investigation of attributing negative social treatment to racial discrimination. J. Cogn. Neurosci. doi:10.1162/jocn.2010.21520.
Masten, C.L., Telzer, E.H., Fuligni, A.J., Lieberman, M.D., Eisenberger, N.I., 2010b. Time spent with friends in adolescence relates to less neural sensitivity to later peer rejection. Soc. Cogn. Affect. Neurosci. doi:10.1093/scan/nsq098.
Mathur, V.A., Harada, T., Lipke, T., Chiao, J.Y., 2010. Neural basis of extraordinary empathy and altruistic motivation. Neuroimage 51, 1468–1475.
Mitchell, J.P., Banaji, M.R., Macrae, C.N., 2005. The link between social cognition and self-referential thought in the medial prefrontal cortex. J. Cogn. Neurosci. 17, 1306–1315.
Mitchell, J.P., Mason, M.F., Macrae, C.N., Banaji, M.R., 2006. Thinking about others: The neural substrates of social cognition. In: Cacioppo, J.T., Visser, P.S., Pickett, C.L. (Eds.), Social Neuroscience: people thinking about thinking people. MIT Press, Cambridge, MA, pp. 63–82.
Mobbs, D., Yu, R., Meyer, M., Passamonti, L., Seymour, B., Calder, A.J., Schweizer, S., Frith, C.D., Dalgleish, T., 2009. A key role for similarity in vicarious reward. Science 324, 900.
Oswald, P.A., 1996. The effects of cognitive and affective perspective taking on empathic concern and altruistic helping. J. Soc. Psychol. 136, 613–623.
Preacher, K.J., Hayes, A.F., 2004. SPSS and SAS procedures for estimating indirect effects in simple mediation models. Behav. Res. Meth. Instrum. Comput. 36, 717–731.
Preacher, K.J., Hayes, A.F., 2008. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Behav. Res. Meth. 40, 879–891.
Rankin, K.P., Gorno-Tempini, M.L., Allison, S.C., Stanley, C.M., Glenn, S., Weiner, M.W., Miller, B.L., 2006. Structural anatomy of empathy in neurodegenerative disease. Brain 129, 2945–2956.
Schroeder, D.A., Dovidio, J.F., Sibicky, M.E., Matthews, L.L., Allen, J.L., 1988. Empathic concern and helping behavior: egoism or altruism? J. Exp. Soc. Psychol. 24, 333–353.
Shrout, P.E., Bolger, N., 2002. Mediation in experimental and nonexperimental studies: new procedures and recommendations. Psychol. Meth. 7, 422–445.
Shamay-Tsoory, S.G., Aharon-Peretz, J., Perry, D., 2009. Two systems for empathy: a double dissociation between emotional and cognitive empathy in inferior frontal gyrus versus ventromedial prefrontal lesions. Brain J. Neurol. 132, 617–627.
Shamay-Tsoory, S.G., Tomer, R., Berger, B.D., Goldsher, D., Aharon-Peretz, J., 2005. Impaired "affective theory of mind" is associated with right ventromedial prefrontal damage. Cogn. Behav. Neurol. 18, 55–67.
Shamay-Tsoory, S.G., Tomer, R., Berger, B.D., Goldsher, D., Aharon-Peretz, J., 2003. Characterization of empathy deficits following prefrontal brain damage: the role of the right ventromedial prefrontal cortex. J. Cogn. Neurosci. 151, 324–337.
Singer, T., 2006. The neuronal basis and ontogeny of empathy and mind reading: review of literature and implications for future research. Neurosci. Biobehav. Rev. 30, 855–863.
Singer, T., Seymour, B., O'Doherty, J.P., Kaube, H., Dolan, R.J., Frith, C.D., 2004. Empathy for pain involves the affective but not sensory components of pain. Science 303, 1157–1162.
Singer, T., Seymour, B., O'Doherty, J.P., Stephan, K.E., Dolan, R.J., Frith, C.D., 2006. Empathic neural responses are modulated by the perceived fairness of others. Nature 439, 466–469.
Sobel, M.E., 1982. Asymptotic confidence intervals for indirect effects in structural equation models. In: Leinhardt, S. (Ed.), Sociological methodology. Jossey-Bass, San Francisco, pp. 290–312.
van Beest, I., Williams, K.D., 2006. When inclusion costs and ostracism pays, ostracism still hurts. J. Pers. Soc. Psychol. 91, 918–928.

Way, B.M., Taylor, S.E., Eisenberger, N.I., 2009. Variation in the mu-opioid receptor gene (OPRM1) is associated with dispositional and neural sensitivity to social rejection. Proceedings of the National Academy of Sciences 106, 15079–15084.

Williams, K.D., Cheung, C.K., Choi, W., 2000. Cyberostracism: effects of being ignored over the Internet. J. Pers. Soc. Psychol. 79, 748.

Williams, K.D., Govan, C.L., Croker, V., Tynan, D., Cruickshank, M., Lam, A., 2002. Investigations into differences between social- and cyberostracism. Group dynamics: theory research, and practice: Special issue: groups and internet, vol. 6, pp. 65–77.

Zadro, L., Williams, K.D., Richardson, R., 2004. How low can you go? Ostracism by a computer is sufficient to lower self-reported levels of belonging, control, self-esteem, and meaningful existence. J. Exp. Soc. Psychol. 40, 560–567.