



Psychopathy is associated with fear-specific reductions in neural activity during affective perspective-taking

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ARTICLE INFO

Keywords:

Psychopathy

Fmri

Social cognition

Emotion

Empathy

Psychopathology

ABSTRACT

Psychopathic individuals are notorious for their callous disregard for others' emotions. Prior research has linked psychopathy to deficits in affective mechanisms underlying empathy (e.g., affective sharing), yet research relating psychopathy to cognitive mechanisms underlying empathy (e.g., affective perspective-taking and Theory of Mind) requires further clarification. To elucidate the neurobiology of cognitive mechanisms of empathy in psychopathy, we administered an fMRI task and tested for global as well as emotion-specific deficits in affective perspective-taking. Adult male incarcerated offenders ($N = 94$) viewed images of two people interacting, with one individual's face obscured by a shape. Participants were cued to either identify the emotion of the obscured individual or identify the shape from one of two emotion or shape choices presented on each trial. Target emotions included anger, fear, happiness, sadness, and neutral. Contrary to predictions, psychopathy was unrelated to neural activity in the Affective Perspective-taking > Shape contrast. In line with predictions, psychopathy was negatively related to task accuracy during affective perspective-taking for fear, happiness, and sadness. Psychopathy was related to reduced hemodynamic activity exclusively during fear perspective-taking in several areas: left anterior insula extending into posterior orbitofrontal cortex, right precuneus, left superior parietal lobule, and left superior occipital cortex. Although much prior research has emphasized psychopathy-related abnormalities in affective mechanisms mediating empathy, current results add to growing evidence of psychopathy-related abnormalities in a cognitive mechanism related to empathy. These findings highlight brain regions that are hypoactive in psychopathy when explicitly processing another's fear.

1. Introduction

Psychopathy is a personality disorder characterized by lack of empathy, grandiosity, an impulsive and irresponsible lifestyle, and habitual antisociality. Present in roughly a quarter of adult prison inmates (Hare, 2003), psychopathy is a significant predictor of violent crime and recidivism (Harris et al., 1991). The disorder has been estimated to cost the U.S. alone \$460 billion dollars per year, making it one of the most costly mental health disorders (Kiehl and Hoffman, 2011). Specifying the neurobiological mechanisms underlying the core features of

psychopathy could lead to more targeted and effective treatments for psychopathic offenders.

Lack of empathy is considered a core deficit in psychopathy (Blair et al., 2005; Soderstrom, 2003). Although definitions of empathy abound, there is general consensus that the process of understanding and responding to another individual's affective state is supported by several interacting mechanisms (Decety, 2015; Decety and Jackson, 2004; Lamm and Majdandžić, 2015). Most contemporary researchers focus especially on affective and cognitive mechanisms underlying empathy. Whereas affective mechanisms (central to empathy, according to

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<https://doi.org/10.1016/j.neuroimage.2020.117342>

Received 3 March 2020; Received in revised form 18 August 2020; Accepted 31 August 2020

Available online 6 September 2020

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Lamm and Majdandžić, 2015) include processes such as affective sharing and physiological arousal to another's emotion, cognitive mechanisms linked to empathy include affective perspective-taking: adopting another's perspective to understand their emotional state. In support of this delineation, these mechanisms recruit activity in overlapping brain regions (left anterior insula) and in distinct brain regions (affective: right anterior insula, right dorsal anterior cingulate, right dorsal medial thalamus, and midbrain; cognitive: left orbitofrontal cortex, left anterior midcingulate, and left dorsal medial thalamus; Fan et al., 2011). Some researchers have also labelled Theory of Mind (ToM), which involves taking another's perspective to understand their beliefs and mental state, as a cognitive mechanism of empathy (Cerniglia et al., 2019; Shamay-Tsoory et al., 2010). As noted below, findings for affective perspective-taking sometimes differ from those for ToM; consequently, for clarity, we distinguish affective perspective-taking from ToM.

Numerous laboratory studies have linked psychopathy to reduced capacity for affective empathy (Blair, 2005b). For example, psychopathic individuals have exhibited reduced physiological arousal (i.e., skin conductance) in response to another person's distress (Aniskiewicz, 1979; Blair et al., 1997; House and Milligan, 1976). When confronted with facial or vocal cues of another person's emotion, psychopathic individuals often show impaired affect recognition (especially for fear, happiness, sadness, and surprise; Dawel et al., 2012). However, it is possible that both affective and cognitive mechanisms of empathy contribute to facial affect recognition. Findings from neuroimaging studies of facial emotion and pain processing have also been interpreted as suggesting deficits in affective empathy. In several studies, psychopathic individuals have displayed attenuated neural response to facial emotion expressions in amygdala, ventromedial prefrontal cortex, dorsomedial prefrontal cortex, anterior insula, and inferior frontal gyrus (Decety et al., 2014; Dolan and Fullam, 2009; Gordon et al., 2004; Sethi et al., 2018). Similarly, psychopathic individuals show attenuated neural responses to others experiencing pain in ventromedial prefrontal cortex, midcingulate cortex, anterior insula, and inferior frontal gyrus (Decety et al., 2015, 2013; Meffert et al., 2013). Each of these regions is recruited during emotional arousal in healthy individuals (Lindquist et al., 2016). Thus, psychopathy appears to be characterized by diminished physiological arousal and neural response to others' emotions.

Yet the extant literature on cognitive mechanisms underlying empathy in psychopathy requires further clarification. Although earlier studies suggested intact capacity for ToM in psychopathic individuals (e.g., Blair, 2005b), recent work suggests distinct impairments in affective perspective-taking (Brook and Kosson, 2013; Decety et al., 2013). More concretely, one study found that psychopathy was associated with poorer accuracy when inferring another person's emotional state from video recordings of the person describing actual emotional life events (Brook and Kosson, 2013). In another study, psychopathy was negatively related to accuracy during affective perspective-taking, but unrelated to accuracy during ToM (Shamay-Tsoory et al., 2010). Furthermore, when adopting the perspective of another person in pain, psychopathic offenders showed significantly less neural activity than non-psychopathic offenders in regions involved in empathy (anterior insula and anterior midcingulate) and mentalizing (medial prefrontal cortex; Decety et al., 2013). These apparent discrepancies can be resolved by distinguishing between aspects of perspective-taking related to another person's knowledge or beliefs (intact in psychopathy) versus aspects of perspective-taking related to another person's affective state (deficient in psychopathy; e.g., Brook and Kosson, 2013; Decety et al., 2013; Shamay-Tsoory et al., 2010).

Similar to adults with psychopathy, juveniles with conduct disorder and callous-unemotional traits show impairments in affective empathy but not ToM (Jones et al., 2010; Schwenck et al., 2012). Some prior studies of youth with conduct problems and callous-unemotional traits also suggest an impairment in affective perspective-taking, with two studies reporting behavioral impairment in this domain (Anastassiou-Hadjicharalambous and Warden, 2008; Lui et al., 2016). Although two

other studies found no behavioral impairment in affective perspective-taking per se (Schwenck et al., 2012; Sebastian et al., 2012), one of these studies linked callous-unemotional traits to reduced activity in right amygdala during affective perspective-taking (Sebastian et al., 2012). Despite these findings, our understanding of the neural correlates of adult psychopathy during perspective-taking for emotional experiences other than pain is quite limited.

To this end, we administered an affective perspective-taking task with five emotion categories (anger, fear, happiness, sadness, and neutral) to incarcerated offenders. Psychopathy was predicted to be negatively related to neural activity in regions involved in cognitive mechanisms underlying empathy (left anterior insula, left orbitofrontal cortex, left anterior midcingulate, and left dorsal medial thalamus; Fan et al., 2011) during the affective perspective-taking task, relative to a secondary shape-matching task. Furthermore, we sought to determine which emotions elicit reduced neural activity during affective perspective-taking. Based on prior findings (Dawel et al., 2012), psychopathy was predicted to be negatively related to task accuracy and neural activity during perspective-taking for fear, sadness, and happiness, but not anger.

For the sake of transparency, we note that this study was originally designed to also provide tests of the predictions of four etiological theories of psychopathy. However, because manipulation tests demonstrated that the preconditions for testing several theories were not met, description of these theory-based predictions has been relegated to **Supplemental Materials**. Thus, this report focuses on: 1) assessing the generality of the affective perspective-taking deficit in psychopathy, and 2) assessing the possibility of anomalies in brain responsiveness to conditions eliciting affective perspective-taking. Nonetheless, where theoretical perspectives on psychopathy appear useful for understanding observed findings, these perspectives are addressed briefly in the Discussion.

2. Methods and materials

2.1. Participants

Adult male inmates were recruited from two medium-security correctional facilities in Wisconsin. All participants met the following inclusion criteria: between ages 18 and 55; no history of psychosis, bipolar disorder, PTSD, epilepsy or stroke; not currently using psychotropic medications; no history of head injury with loss of consciousness >30 min; >4th grade English reading level; intact auditory and visual capabilities; IQ >70; and no MRI contraindications. One hundred participants met inclusion criteria and finished the fMRI task. Six participants were excluded from analyses (three participants did not demonstrate adequate learning of the task, two encountered technical errors, and one had excessive head motion on more than 20% of time points), leaving a final sample of $N = 94$. All subjects provided written informed consent. The study was approved by the IRBs at the universities of the last three authors.

2.2. Assessments

Psychopathy was assessed with the Psychopathy Checklist-Revised (PCL-R; Hare, 2003), which is scored on the basis of a semi-structured interview and file review. The 20 PCL-R items were rated on a scale of 0–2, yielding total scores between 0 and 40 (Hare et al., 1990). Although intra-class correlations (ICC) of PCL-R Total scores for the current sample were unavailable, prior PCL-R data from our lab show high inter-rater reliability ($N = 129$, $ICC = 0.97$).

IQ was estimated from the Wechsler Adult Intelligence Scale 3rd Ed. (WAIS-III; Wechsler, 1997) vocabulary and matrix reasoning scales. Lifetime substance use disorder diagnoses were determined using the Structured Clinical Interview for the DSM-IV (SCID-IV; First et al., 2012). To minimize the number of covariates used in statistical models, a single dichotomous variable was calculated for substance use disorder (present

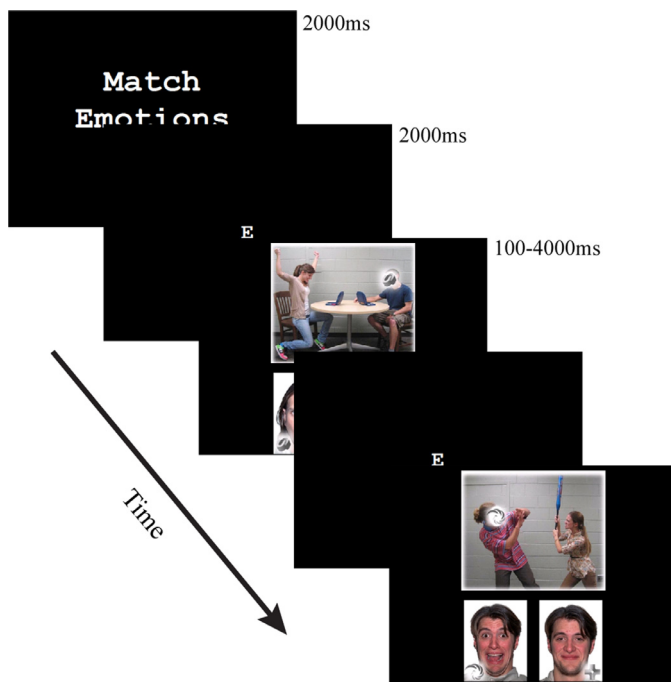


Fig. 1. Temporal sequence of the affective perspective-taking task. Participants selected one of two emotional faces that best matched the emotion of the obscured face from the social scene. For the shape task, participants selected one of two shapes that matched the shape embedded within the social scene.

or absent), based on whether each participant met criteria for abuse or dependence on any substance (alcohol, cannabis, cocaine, opioids, stimulants, sedatives, or hallucinogens) in his lifetime (Korponay et al., 2016; Wolf et al., 2015).

2.3. Behavioral tasks

Participants viewed static images portraying two individuals interacting (e.g., one person scolding the other, one person consoling the other), with one individual's face obscured by a shape (see Fig. 1; Haas et al., 2015). The affective perspective-taking task (half the trials) required participants to decide which of two emotional faces best matched the obscured face from the social scene. Prior research has found this affective perspective-taking task to elicit neural activity within the 'empathy network', including insula, medial prefrontal cortex, and precuneus (Haas et al., 2015). The shape task (the other half of trials) required participants to indicate which of two shapes matched the shape embedded within the social scene. Thus, each task presented the same visual stimuli and required participants to visually search both the social scene at the top of the screen and the response options at the bottom. All responses were recorded via response box.

The task was administered in four runs of 35 trials, resulting in a total of 140 trials. The social scenes were divided evenly among five emotion categories (anger, fear, happiness, sadness, and neutral), with the emotions task-relevant only for 70 trials (i.e., the affective perspective-taking trials). Trials were presented in blocks of 3 or 4 trials, alternating between the affective perspective-taking and shape tasks. Each trial began with the presentation of a letter denoting the task, followed by the stimulus (mean presentation time 1.8 s, range 0.1–4.0 s), and finally a fixation cross before the next trial (2 s). A performance-based monetary reward was offered on the third and fourth runs (see **Supplemental Materials** for details). Our principal analyses collapsed across rewarded and non-rewarded conditions.

2.4. fMRI acquisition

Imaging data were collected on prison grounds in the Mind Research Network's 1.5 T mobile imaging unit, using a 32-channel head coil. Multiband echo planar images (EPIs) were collected with the following parameters: TR=350 ms, TE=39.0 ms, flip angle=38°, FOV=248 × 248 mm, phase encoding direction=anterior to posterior, slice thickness=3.5 mm, voxel size=3.5 × 3.5 × 3.5mm³, 48 slices per volume and a total of 3347 vol (Feinberg and Setsompop, 2013). High-resolution T1-weighted anatomical scans were collected for each subject (TR=2400 ms, TE=1.9 ms, flip angle=8°, FOV=256 × 256mm², slice thickness=1.00 mm, voxel size=1 × 1 × 1mm³ and 176 interleaved sagittal slices).

2.5. Task performance analysis

Correct responses were summed for each of the five emotions and two tasks. These responses were then entered into linear mixed effects models for the Affective Perspective-Taking > Shape contrast, as well as the Fear > Neutral, Sadness > Neutral, Happiness > Neutral, and Anger > Neutral contrasts within the affective perspective-taking task. We first modeled task accuracy across all participants, then modeled task accuracy in relation to PCL-R Total scores. Average response times (RTs) were modeled in the same manner.

2.6. fMRI analysis

fMRI data were processed using AFNI (16.0; Cox, 1996). Two EPI spin-echo sequences (one in the anterior-to-posterior phase encoding direction; one in the posterior-to-anterior direction) were used to correct geometric distortions due to field inhomogeneity. EPI volumes were motion corrected by rigid body alignment, using the first volume as a reference. Next, EPIs were smoothed with a 6 mm full-width-at-half-maximum Gaussian kernel and scaled to a mean of 100. The T1-weighted anatomical scans were skull-stripped and intensity normalized. EPIs were then aligned to the anatomical scans, and both were aligned to MNI-152 template space. Finally, the four EPI runs were concatenated and modeled with two regressors for each stimulus category, representing stimulus onsets and their temporal derivatives (3dDeconvolve; Calhoun et al., 2004). The first 15 TRs (5.25 s) were censored from each run during this step. Button press times, fixation times, and residual head motion after volume correction were also modeled as regressors of no interest. The resulting statistical maps were entered in general linear tests of the Affective Perspective-Taking > Shape contrast, as well as the Fear > Neutral, Sadness > Neutral, Happiness > Neutral, and Anger > Neutral contrasts within the affective perspective-taking task.

At the final analysis stage, PCL-R Total score was entered as a regressor with the contrasts of interest in separate, whole-brain general linear models. Principal analyses also included age, race/ethnicity, IQ (WAIS-III) and substance use disorder diagnosis (SCID-IV) as covariates. Additional analyses were conducted without the covariates. Hemodynamic responses were considered significant at $p_{FWE} < 0.05$ (cluster size > 11 voxels, uncorrected $p = .002$). Monte Carlo simulations (3dFWHMx and 3dClustSim) determined the cluster extent threshold (postprocessing FWHM = 9.21; Cox et al., 2017; Eklund et al., 2016). To control for testing multiple contrasts, principal analyses were also checked at a Bonferroni-corrected level of $p_{FWE} < 0.01$ ($p_{FWE} = 0.05/5$ contrasts = 0.01; cluster size > 14, uncorrected $p = .002$).

3. Results

3.1. Participant Characteristics

Participant characteristics are displayed in **Table 1**. Neither age, $r = 0.05$, $p = .62$, nor IQ, $r = 0.09$, $p = .38$, was significantly correlated with PCL-R Total scores. However, non-white participants ($M = 25.2$,

Table 1
Participant characteristics ($n = 94$).

Measure	M (SD)	Range
PCL-R Total	23.3 (7.0)	8.4–37.0
Age	32.9 (8.2)	20.0–52.0
IQ	97.7 (13.9)	72.0–134.0
Measure	%	
Proportion Caucasian	53.2%	
Proportion with Substance Use Disorder	76.6%	

SD = 6.7) had higher PCL-R Total scores than white participants ($M = 21.6$, $SD = 7.0$), $F(1, 92) = 6.27$, $p < .02$. Furthermore, participants with a substance use disorder ($M = 24.4$, $SD = 6.4$) had higher PCL-R Total scores than participants without a substance use disorder ($M = 19.7$, $SD = 8.0$), $F(1, 92) = 7.94$, $p < .01$.

3.2. Task performance results across participants

Participants were significantly more accurate in the shape task (mean accuracy = 88.7%) than the affective perspective-taking task (72.7%), $F(1, 93) = 207.99$, $p < .001$. During the affective perspective-taking task, participants were generally more accurate on trials with emotional compared to neutral content, a difference that was statistically significant for two of four emotions. Compared to neutral trials (mean accuracy = 71.6%), participants were significantly more accurate on sadness trials (75.4%), $F(1, 93) = 4.55$, $p < .04$, and happiness trials (82.6%), $F(1, 93) = 36.54$, $p < .001$. Participants were not significantly more accurate on fear trials (74.8%) than neutral trials, $F(1, 93) = 3.19$, $p = .08$. However, participants were less accurate on anger trials (58.9%) than on neutral trials, $F(1, 93) = 36.00$, $p < .001$.

In addition to being more accurate, participants were faster to respond to the shape task (mean RT = 1.48 s) than to the affective perspective-taking task (2.06 s), $F(1, 93) = 321.89$, $p < .001$. During the affective perspective-taking task, participants responded more quickly on happiness trials (1.92 s) than neutral trials (2.06 s), $F(1, 93) = 38.97$, $p < .001$. However, participants responded more slowly to anger trials (2.11 s), $F(1, 93) = 6.85$, $p < .02$, and sadness trials (2.15 s), $F(1, 93) = 15.11$, $p < .001$, than to neutral trials (2.06 s). Response times for fear trials (2.08 s) did not differ from those for neutral trials (2.06 s), $F(1, 93) = 0.69$, $p = .41$.

3.3. Task performance results related to psychopathy

Psychopathy was unrelated to task accuracy in the Affective Perspective-Taking > Shape contrast, $F(1, 92) = 0.41$, $p = .52$. As predicted, during the affective perspective-taking task higher PCL-R Total scores were related to poorer task accuracy in the Fear > Neutral, $F(1, 92) = 6.59$, $p < .02$, Sadness > Neutral, $F(1, 92) = 4.90$, $p < .03$, and Happiness > Neutral contrasts, $F(1, 92) = 10.19$, $p < .01$. Psychopathy was unrelated to task accuracy in the Anger > Neutral contrast, $F(1, 92) = 1.92$, $p = .17$, during the affective perspective-taking task.

Psychopathy was also unrelated to response times in the Affective Perspective-Taking > Shape contrast, $F(1, 92) = 0.52$, $p = .47$. During the affective perspective-taking task, higher PCL-R Total scores were related to slower response times in the Sadness > Neutral contrast, $F(1, 92) = 4.98$, $p < .03$. Higher PCL-R Total scores were not significantly related to slower response times in the Fear > Neutral contrast, $F(1, 92) = 3.05$, $p = .08$. Psychopathy was also unrelated to response times in the Anger > Neutral, $F(1, 92) = 2.17$, $p = .14$, and Happiness > Neutral contrasts, $F(1, 92) = 1.14$, $p = .29$.

3.4. fMRI results across participants

The task recruited neural regions (Fig. 2) consistent with previous affective perspective-taking studies (Fan et al., 2011), including

studies that used the same task (Haas et al., 2015). The Affective Perspective-Taking > Shape contrast revealed greater activation in areas previously implicated in empathy and mentalizing, such as ventromedial prefrontal cortex, dorsomedial prefrontal cortex, anterior insula (AI), inferior frontal gyrus, and precuneus, all bilaterally ($p_{FWE} < 0.05$; Denny et al., 2012; Fan et al., 2011). Additionally, the affective perspective-taking task elicited greater activation in visual processing regions than the shape task, including inferior occipital gyrus, inferior temporal gyrus, and fusiform gyrus. The contrast also demonstrated several regions showing greater activation in the shape task, including superior temporal gyrus, hippocampus, parahippocampal gyrus, and superior parietal lobule, areas identified in previous shape processing studies (Peelen and Caramazza, 2012).

Main effects across participants showed greater neural activity related to emotional, relative to neutral, content in the affective perspective-taking task, in line with previous studies of emotion processing (Fig. 2; Fusar-Poli et al., 2009; Phan, Wager, Taylor, & Liberzon, 2002). The Fear > Neutral, Sadness > Neutral, and Happiness > Neutral contrasts all indicated greater activity in left hippocampus, right fusiform gyrus, and bilateral precentral gyrus during emotional than during neutral trials. Furthermore, the Fear > Neutral and Sadness > Neutral contrasts elicited greater activity in right inferior temporal gyrus, bilateral middle temporal gyrus, left parahippocampal gyrus, and right occipital cortex during emotional than during neutral trials. The Anger > Neutral contrast likewise recruited greater activity in left parahippocampal gyrus, fusiform gyrus, and middle temporal gyrus during anger than during neutral trials. The Fear > Neutral contrast revealed greater activity in left amygdala during fear than during neutral trials. Finally, the Fear > Neutral and Sadness > Neutral contrasts revealed less activity in rostral anterior cingulate and adjacent ventromedial prefrontal cortex during fear and sadness than during neutral trials.

3.5. fMRI results related to psychopathy

Contrary to our predictions, PCL-R Total scores were unrelated to activity in any brain areas in the Affective Perspective-Taking > Shape contrast.

In the affective perspective-taking task, psychopathy was related to reduced neural activity only during fear trials. PCL-R Total scores were negatively related to Fear > Neutral activity in several regions, including left AI extending into posterior orbitofrontal cortex (pOFC; Fig. 3), right precuneus (Fig. 4), left superior occipital cortex, and left superior parietal lobule (Table 2). This pattern of findings remained after Bonferroni correction and when the covariates were removed from the model. PCL-R Total scores were not significantly related to Happiness > Neutral, Sadness > Neutral, or Anger > Neutral activity in any brain region. As a follow-up analysis, fear trials were contrasted with an aggregate of the remaining emotions [Fear > (Anger + Happiness + Sadness)] for the affective perspective-taking task. PCL-R Total scores were again negatively related to activity in right precuneus, among other regions (Table 2).

Follow-up analyses, including results regarding PCL-R Factor scores, PCL-R groups, trait empathy, and additional analyses related to contemporary theoretical perspectives can be found in the **Supplemental Materials**.

4. Discussion

The current study sought to identify relations between psychopathy and neural activity under conditions demanding affective perspective-taking (a cognitive mechanism of empathy) in a sample of offenders. Although psychopathy was unrelated to neural activity during affective perspective-taking in general, further analyses revealed deficits during perspective-taking for specific emotions, particularly fear. Performance analyses showed that psychopathy was associated with reduced accuracy in the affective perspective-taking task in identifying fear, sadness,

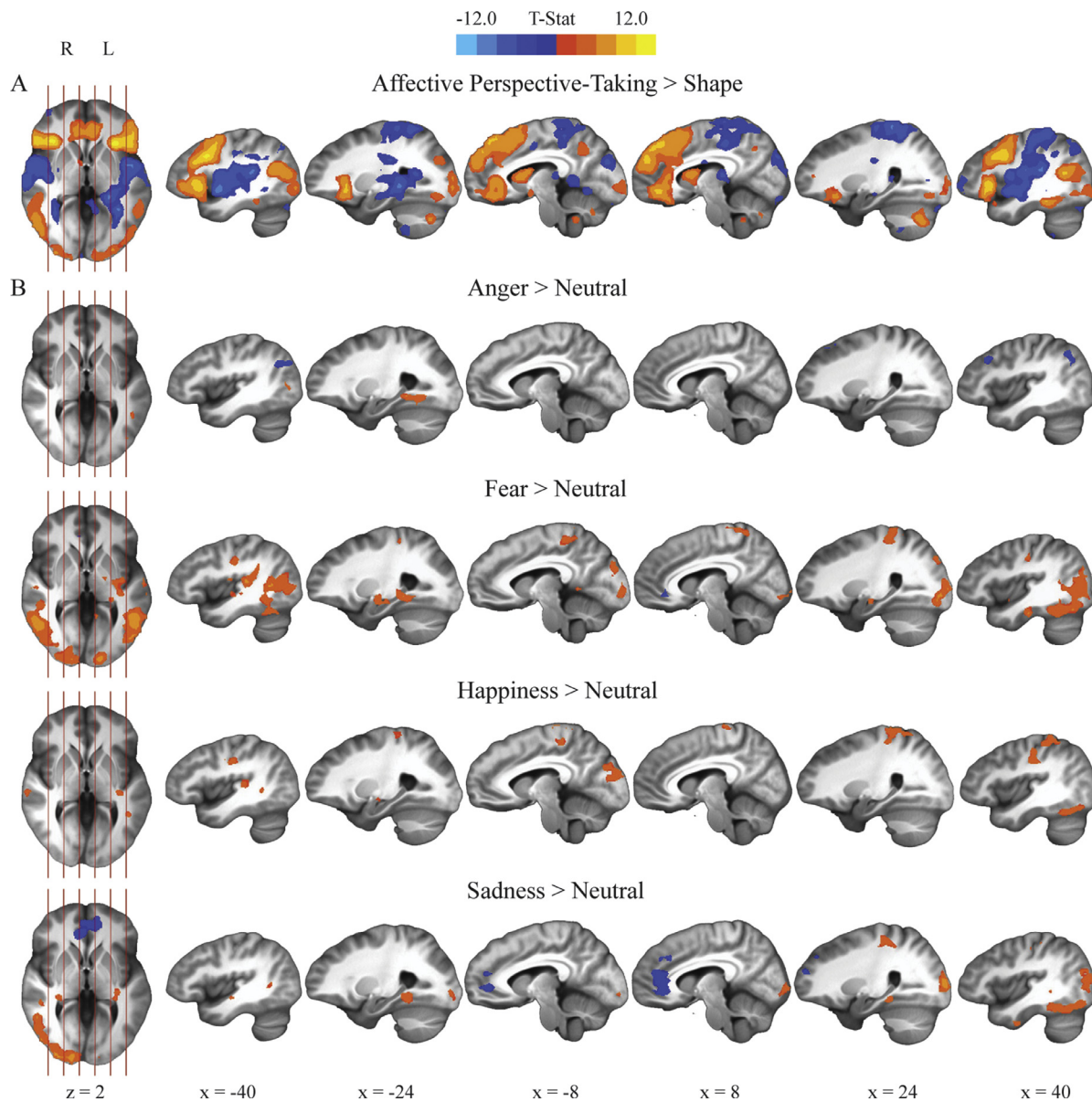


Fig. 2. Areas of significant activation across the entire sample for A) the Affective Perspective-Taking > Shape contrast, and B) the emotion-specific contrasts within the affective perspective-taking task: Anger > Neutral, Fear > Neutral, Sadness > Neutral, and Happiness > Neutral (uncorrected $p = .002$, $p_{FWE} < 0.05$).

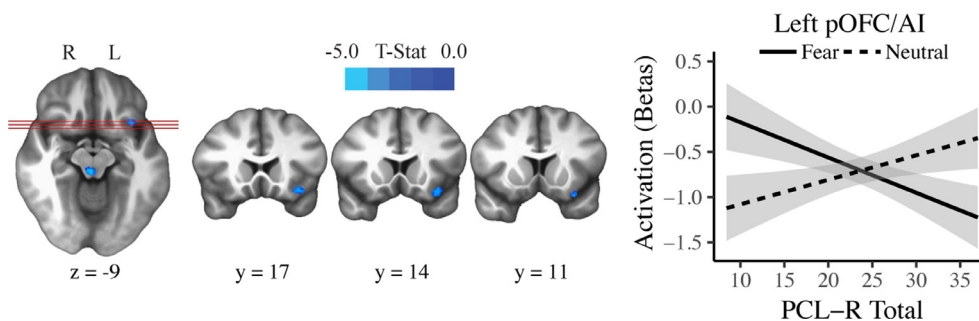


Fig. 3. The significant association between PCL-R Total scores and Fear > Neutral activity in left anterior insula (AI) extending into posterior orbitofrontal cortex (pOFC) in the affective perspective-taking task (uncorrected $p = .002$, $p_{FWE} < 0.05$). The activation plot shows regression lines with error bands representing 1 SE above and below the point estimate of the model.

and happiness. Yet psychopathy was negatively related to neural activation in brain regions involved in empathy, perspective-taking, and visual processing only during fear trials. Here, we review each of these findings in turn.

The behavioral findings described above provide evidence consistent with diminished capacity for affective perspective-taking in psychopa-

thy. Earlier work had argued for disrupted affective mechanisms of empathy (i.e., physiological arousal to another's emotion) but intact ToM (another cognitive mechanism linked with empathy; Blair, 2005b). The current findings and other recent studies suggest a distinct impairment in affective perspective-taking and corroborate the distinction between these two cognitive mechanisms of empathy (Brook and Kosson, 2013;

Table 2

Regions showing significant negative associations between fear contrasts and PCL-R Total scores during the affective perspective-taking task in whole-brain analyses (uncorrected $p = .002$; $p_{FWE} < 0.05$).

Contrast	Brain Region	L/R	MNI Peak Coordinates(x, y, z)	Size (Voxels)	Peak-value
Fear > Neutral	Superior Occipital Cortex	L	-37, -78, 31	36	-3.87
	Superior Parietal Lobule	L	-30, -64, 52	21	-3.82
	Brainstem	R	9, -19, -15	20	-4.01
	Precuneus	R	5, -50, 56	18	-3.78
	Anterior Insula/	L	-30, 13, -15	16	-3.87
Fear > (Anger + Happiness + Sadness)	Posterior Orbitofrontal Cortex				
	Superior Occipital Cortex	R	30, -75, 28	21	-4.20
	Precentral Gyrus	L	-37, -8, 45	18	-4.38
	Postcentral Gyrus	R	33, -43, 52	17	-4.29
	Precuneus	R	9, -64, 52	17	-3.69
	Superior Occipital Cortex	R	30, -85, 14	16	-3.60
	Fusiform Gyrus	L	-26, -36, -11	12	-3.33
	Postcentral Gyrus	L	-40, -33, 52	12	-3.39

All models controlled for age, race/ethnicity, substance abuse and IQ.

In the Fear > Neutral contrast, all regions were additionally significant at a Bonferroni-corrected level of $p_{FWE} < 0.01$ (cluster size > 14, uncorrected $p = .002$).

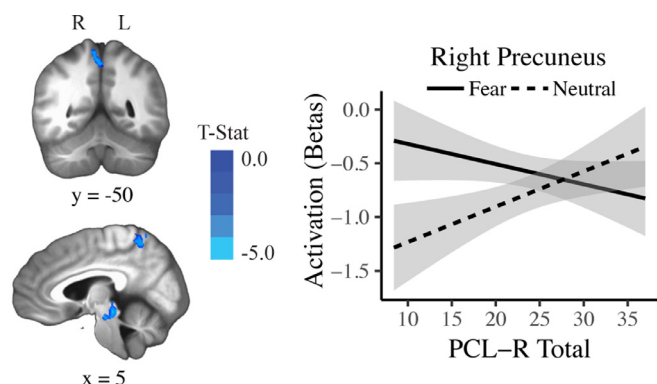


Fig. 4. The significant association between PCL-R Total scores and Fear > Neutral activity in right precuneus in the affective perspective-taking task (uncorrected $p = .002$, $p_{FWE} < 0.05$). The activation plot shows regression lines with error bands representing 1 SE above and below the point estimate of the model.

Decety et al., 2013; Shamay-Tsoory et al., 2010). Recent studies have found behavioral deficits in affective perspective-taking generally (Shamay-Tsoory et al., 2010) and specifically for fear and sadness (Brook and Kosson, 2013), as well as neural deficits during perspective-taking for pain (Decety et al., 2013). The current study extends these findings to include reduced neural activity during fear perspective-taking.

Recent neuroimaging studies have also examined psychopathic offenders' affective perspective-taking deficits in scenarios involving pain (Decety et al., 2013), social exclusion, and love (Meffert et al., 2013). Growing evidence from these studies suggests that psychopathic individuals fail to automatically and spontaneously adopt the perspective of others. In one study, psychopathic individuals showed greater neural abnormalities while passively viewing emotional scenarios, compared to when asked to actively empathize with the actors in the scenarios (Meffert et al., 2013). Similarly, psychopathic offenders failed to automatically take another's perspective during a non-emotional task (an avatar dot-counting task; Drayton et al., 2018). In the current study, participants were explicitly instructed to take another's perspective in one of two tasks. Future studies might predict psychopathic offenders to exhibit more pronounced reductions in neural activity under passive viewing conditions, compared to the instructed affective perspective-taking task administered in this study. Nevertheless, the current study adds to previous evidence of reduced neural activity in key empathy re-

gions when psychopathic individuals are explicitly instructed to adopt another's perspective (Decety et al., 2013).

A pattern of attenuated neural response in psychopathy was observed in two key regions involved in empathy and emotion, left AI and left pOFC. The subregion of AI observed in this study appears to subservise social-emotional functions, including empathy (Fan et al., 2011; Singer et al., 2004) and the experience of emotion (Kurth et al., 2010; Lindquist et al., 2012). Furthermore, left AI, as observed in this study, appears involved in both affective and cognitive mechanisms of empathy (whereas right AI is involved primarily in affective mechanisms of empathy; Fan et al., 2011). It has been proposed that AI facilitates empathy by integrating external and visceral information in order to predict another person's emotional state (Singer et al., 2009). Across a variety of forms of social cognition, psychopathy has been consistently related to reduced AI activity. When imagining another person in pain, psychopathic offenders show attenuated bilateral AI activity (Decety et al., 2013). Moreover, psychopathic traits are negatively related to AI activity when administering punishment to others (Molenberghs et al., 2014), anticipating guilt for moral transgressions (Seara-Cardoso et al., 2016) and responding emotionally to others' affective faces (Seara-Cardoso et al., 2016) in community samples. The left AI in psychopathic offenders has also been reported to be thinner and less functionally connected to dorsal anterior cingulate cortex, another important node in the empathy network (Ly et al., 2012; Philippi et al., 2015). The current study adds to a growing body of literature identifying AI as an important region of neural dysfunction in psychopathy.

Alternative explanations of this study's AI findings may be addressed in future research. For example, AI is also involved in processing uncertainty (Singer et al., 2009). Thus, the present AI findings may reflect diminished capacity to represent uncertain information in social scenes in psychopathic individuals. Future studies may use computational modeling as in Brazil et al. (2017) to determine how AI represents uncertain information during affective perspective-taking in psychopathy. Relatedly, the present findings may reflect disrupted processing of threat cues in psychopathy. Although early research suggested global deficits in fear processing in psychopathy (Lykken, 1957), recent literature suggests a more specific deficit in threat processing, rather than an attenuated conscious experience of fear (Hoppenbrouwers et al., 2016). Taking the perspective of the target individual in the fear trials of the current study required identifying the presence of threat cues in the social scene (e.g., a spider or an assailant with a bat). Reduced activity of left AI, which also plays a role in threat processing (Pichon et al., 2012), may partly reflect disrupted processing of threat cues in psychopathy. Future studies could manipulate the focus to or away from threat cues in the social scene to determine the kinds of information to which left AI is responding dur-

ing affective perspective-taking in psychopathic and non-psychopathic individuals.

Posterior OFC shares dense interconnections with the amygdala, and this pathway is thought to be critical for emotion processing (Timbie and Barbas, 2014). Receiving information about emotional context from the amygdala, pOFC appears to be involved in modulating the intensity of emotional experience through feedback connections to the amygdala and autonomic structures (Barbas, 2007). Psychopathic individuals consistently show OFC dysfunction while processing emotional stimuli (Blair, 2010), and several theories of psychopathy pinpoint OFC as a key region of dysfunction, including the Integrated Emotion Systems perspective (Blair, 2005a) and Paralimbic Hypothesis (Kiehl, 2006), with the latter also predicting AI dysfunction in psychopathy. Although current OFC findings corroborate these accounts, these theories do not explain our findings of links between psychopathy and anomalies in other regions, such as precuneus and visual cortex. For example, does reduced activity in these regions reflect downstream effects of reduced activation of paralimbic regions, such as pOFC, AI, and amygdala? Or does the reduced activity arise from dysfunction within these non-paralimbic brain areas? Future studies and neurobiological accounts of psychopathy should address the relatively consistent observations of dysfunction in regions both within and outside the paralimbic cortex (Deming and Koenigs, 2020; Koenigs et al., 2011).

The following limitations should be considered when interpreting the current results. First, one of the original goals of the study was to test the predictions of four etiological theories of psychopathy. The utility of these tests was not corroborated by most of the manipulation checks we conducted. Consequently, we did not use this paradigm to test these specific theoretical perspectives. Future studies may continue to develop manipulations that contribute to better tests of these theories, as well as manipulations that provide more powerful tests of the conditions under which psychopathic individuals display affective perspective-taking deficits. Studies like the current study are important in providing evidence that is needed in order to extend psychological theories of psychopathy to the neural substrates of social processes such as empathy. In this context, the current findings provide important insight into psychopathic individuals' behavioral and neural responses when taking another's perspective to understand their affective state. Next, the difference in difficulty between the affective perspective-taking and shape tasks may have undermined our ability to detect a relationship between psychopathy and Affective Perspective-Taking > Shape activity. Additionally, the lack of psychopathy-related neural findings during perspective-taking for sadness and happiness was unexpected, given that psychopathy was negatively related to task accuracy during these trials. Although fMRI analyses can be more sensitive than behavioral analyses (Raemaekers et al., 2006; Whalen et al., 1998), the absence of fMRI findings related to happiness and sadness in this study may stem from our reliance on corrected whole-brain analyses, which are less powerful than region of interest analyses, or from low power as a result of the relatively small number of trials (14) per emotion. Even so, this pattern raises the possibility that some brain systems in psychopathic offenders are under at least some conditions less responsive to fear cues than to cues for other emotions.

In sum, we have identified a set of brain regions whose activity may underlie some of the social cognitive deficits observed in psychopathy. Whereas some prior concepts of empathic deficits in psychopathy have emphasized the affective mechanisms of empathy, the current study adds to recent findings of an impaired cognitive mechanism of empathy and points to specific brain regions previously linked to cognitive mechanisms of empathy and mentalizing as candidate substrates of this impairment.

5. Financial disclosures

The authors declare no competing financial interests.

CRediT authorship contribution statement

Philip Deming: Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Visualization. **Monika Dargis:** Project administration. **Brian W. Haas:** Software. **Michael Brook:** Conceptualization, Software. **Jean Decety:** Writing - review & editing. **Carla Harenski:** Writing - review & editing, Supervision. **Kent A. Kiehl:** Conceptualization, Methodology, Writing - review & editing, Supervision. **Michael Koenigs:** Writing - review & editing, Supervision. **David S. Kosson:** Conceptualization, Methodology, Writing - review & editing.

Acknowledgments

We thank the many individuals at the Wisconsin Department of Corrections who made this research possible, and are especially indebted to Deputy Warden Tom Nickel, Warden Randy Hepp, and Dr. Kevin Kallas. We thank Keith Harenski for managing fMRI data collection, and Vince Calhoun and Rasmus Birn for consulting on fMRI analyses. Authors D.K., M.K. and P.D. had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. This work was supported by grants from the National Institutes of Health R01MH090169 to David Kosson, and R01MH087525-01 and R01MH109329 to Jean Decety.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.neuroimage.2020.117342.

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