Functional Differences Among Those High and Low on a Trait Measure of Psychopathy

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Background: *It has been established that individuals who score high on measures of psychopathy demonstrate difficulty when performing tasks requiring the interpretation of other's emotional states. The aim of this study was to elucidate the relation of emotion and cognition to individual differences on a standard psychopathy personality inventory (PPI) among a nonpsychiatric population.*

Methods: *Twenty participants completed the PPI. Following survey completion, a mean split of their scores on the emotional–interpersonal factor was performed, and participants were placed into a high or low group. Functional magnetic resonance imaging data were collected while participants performed a recognition task that required attention be given to either the affect or identity of target stimuli.*

Results: *No significant behavioral differences were found. In response to the affect recognition task, significant differences between high- and low-scoring subjects were observed in several subregions of the frontal cortex, as well as the amygdala. No significant differences were found between the groups in response to the identity recognition condition.*

Conclusions: *Results indicate that participants scoring high on the PPI, although not behaviorally distinct, demonstrate a significantly different pattern of neural activity (as measured by blood oxygen level–dependent contrast) in response to tasks that require affective processing. The results suggest a unique neural signature associated with personality differences in a nonpsychiatric population.*

Key Words: Amygdala, emotion recognition, functional magnetic resonance imaging (fMRI), inferior frontal, psychopathy, Psychopathy Personality Inventory (PPI)

Psychopathy is a personality disorder associated with a variety of behavioral attributes including narcissism, impulsivity, manipulativeness, and tendencies toward self-promotion. One hallmark of the psychopathic individual is difficulty in processing emotional information. In this regard, psychopaths have been found to differ significantly from nonpsychopathic individuals in their explicit behavioral responses, implicit behavioral responses, and cognitive strategies (Day and Wong 1996; Kiehl et al 1999; Kosson et al 2002; Patrick et al 1994). Among psychopathic populations, tasks requiring the labeling of affective stimuli have consistently reported discrepancies in speed of responding using verbal stimuli (Williamson et al 1991) and accuracy of responding using nonverbal stimuli (Day and Wong 1996; Habel et al 2002; Kosson et al 2002). It has been posited that the observed deficits in psychopathic individuals result from a decreased sensitivity to the emotional properties of the stimuli. This idea of reduced sensitivity has also received support from psychophysiologic studies.

Patrick et al (1994) reported a significant reduction in psychophysiologic response among psychopaths, compared with nonpsychopaths, during imagery of fearful scenes. Although both groups reported comparable feelings of fearfulness, imagery ability, and imagery experience, psychopaths showed attenuated heart rate and reduced skin conductance during fearful imagery (Patrick et al 1994). A generalized decrease in emotional responsivity, as measured by the Affect Intensity Measure, has also been observed among psychopathic individuals (Day and Wong 1996). When measuring startle response and heart rate, psychopaths consistently manifest blunted autonomic responses to scenes depicting victim violence and other forms of threat, as well as distress cues (Blair et al 1997). The notion that emotional states are determined by the individual's interpretation of their physiologic response to environmental stimuli is a concept that dates back to the work of William James. The reduction in or absence of physiologic responsivity to affective stimuli is thought to be central to the difficulties related to emotion perception and interpretation commonly associated with psychopathy.

> Without the bodily states following on the perception, the latter would be purely cognitive in form, pale, colorless, destitute of emotional warmth. We might then see the bear, and judge it best to run, receive the insult and deem it right to strike, but we could not actually *feel* afraid or angry. (James 1884)

A purely cognitive response to situations high in emotional content is a central feature among individuals classified as "primary psychopaths" (Blackburn 1975; Karpman 1948; Lykken 1995). In addition to showing blunted physiologic signs of emotional responsivity, primary psychopaths have been described as highly intelligent, socially adept, and manipulative. These individuals stand in sharp contrast to "secondary psychopaths." Secondary psychopaths manifest increased behavioral difficulties, rather than those more closely associated with a personality style. These individuals typically display behavioral impulsivity, social awkwardness, and a lack of moral sensibility (Cleckley 1976). This distinction is important in terms of both brain and behavior. Although it has been relatively easy to study the brain–behavior relation among secondary psychopaths because they display behaviors that more readily bring them to the attention of the criminal justice system, understanding the often subtle personality differences associated with primary psychopathy has been more difficult. Recent imaging research has indicated that individual differences in personality disposition are highly related to patterns of functional activation, particularly within the prefrontal cortex (Gray et al 2002; Gusnard et al 2003).

Dysfunction of specific areas within the frontal cortex, specifically orbital, ventromedial prefrontal, and cingulate cortex,

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have been consistently associated with psychopathy (Damasio et al 1994; Kiehl et al 2001; Raine et al 1994). Historical as well as recent reports have suggested that some but not all of the characteristics associated with psychopathy may also be acquired following damage to these same regions (Anderson et al 1999; Barrash et al 2000; Harlow 1848), implicating these regions in the manifestation of psychopathic behavior. Pathologic lying, irresponsibility, promiscuous sexual behavior, labile affect, and lacking feelings of guilt or remorse are just a few of the behaviors that are seen in persons experiencing ventromedial (Anderson et al 1999) and orbitofrontal damage (Damasio et al 1994). Although damage to these regions does not inevitably result in the development of psychopathic behavior, individuals with this type of damage are likely to demonstrate behaviors associated with psychopathy (i.e., impulsivity, remorselessness, problems with emotional processing).

There is little doubt that disruption of frontal cortical systems contributes significantly to the symptomatology of psychopathy, but it is equally plausible that the neural systems underlying this personality disorder have both local and distributed components (Damasio et al 1994). Blair has argued that a dysfunction of the amygdala may be primarily responsible for behavior associated with psychopathy. It is well established that damage to the amygdala results in impairments with regard to affect recognition (Adolphs et al 2002; Anderson and Phelps 2001). With regard to psychopathy, it is thought that deficits in affect recognition could prevent an individual from experiencing empathy and over the long-term result in the development of antisocial behavior (Blair et al 1997).

To date, the research on neural correlates of psychopathic behavior has focused almost exclusively on clinical or incarcerated populations using primarily the Psychopathy Checklist—Revised (PCL-R; Hare et al 1990) to assess the disorder. Although these investigations have greatly enhanced the understanding of the brain–behavior relation in psychopathy, there are important reasons to study nonclinical populations. First, as is true with a number of pathologic conditions, examination of nonclinical individuals enables investigators to focus on specific aspects of the disorder. Concerning psychopathy, such a focus has the potential to enhance our understanding of the well-documented deficits in emotional processing, while filtering out the heterogeneous effects of psychiatric illness and long-term institutionalization (Kiehl et al 2001; Kirkman 2002). Second, by investigating specific psychopathic traits as they exist along a continuum of behavior within a nonclinical population, it is possible to further elucidate the difference between individual variation and neuropathology. More specifically, without a clear description of variation found within a nonpsychiatric population, it is nearly impossible to determine whether abnormalities in affective processing skills are associated with neuropathologic variation or individual difference.

The Psychopathic Personality Inventory (PPI; Lilienfeld and Andrews 1996) was specifically designed to assess personality psychopathy among nonincarcerated populations and provide the continuum measure necessary to study psychopathy within the general population. Construct validity of this measure was determined through the coadministration of various other metrics of psychopathy, sociopathy, and antisocial behavior during initial development of the scale (Lilienfeld and Andrews 1996). The PPI has been shown to correlate positively (.54) with the PCL-R, providing support for its concurrent validity (Poythress et al 1998). The PCL-R is the most widely used metric of psychopathy in clinical and criminal populations (Hare et al 1990). Researchers have recently uncovered a dual factor structure of the PPI. This new structure segments the subscales of the PPI into two factors: emotional–interpersonal and socially deviant (Benning et al 2003), mirroring that of the PCL-R (Hare et al 1990). The subscales associated with the emotional–interpersonal dimension are social potency, stress immunity, and fearlessness, which more closely reflect an individual's relative possession of Factor 1 of the PCL-R. Factor 1 of the PCL-R is associated with a low anxious and socially dominant personality (Harpur et al 1989; Patrick et al 1994) and is considered to represent the core psychopathic traits (Hare 2003). The subscales of the PPI associated with the social deviance dimension are carefree nonplanfulness, blame externalization, Machiavellian egocentricity, and impulsive nonconformity, providing a metric of participants' relative possession of Factor 2 of the PCL-R (Benning et al 2003). Factor 2 of the PCL-R represents the behaviorally antisocial and impulsive components of the psychopathic personality. Psychopathic populations that have been split based on their relative scores on the individual factors of the PCL-R have demonstrated unique psychophysiologic (Patrick et al 1994; Verona et al 2004) responses to emotional stimuli, including heart rate and skin conductance responsivity. With the advent of an analogous factor structure of the PPI similar investigations can be carried out within the general population.

Using a nonpsychiatric sample, this study sought to use individual differences on a trait measure of psychopathy to assess both behavior and neural activity during performance of an affect recognition task. Based on the substantial evidence indicating impaired affective processing among psychopaths, we hypothesized that controlling for individual differences on a trait measure of psychopathy would reveal unique patterns of neural activity. We further hypothesized that these differences would be most evident in regions known to be heavily involved in the processing of affective stimuli (i.e., amygdala and prefrontal cortex). Specifically, we expected to find that those who scored higher on the emotional–interpersonal factor of the PPI to use alternate strategies when performing a task requiring emotion recognition compared with those participants who scored lower on the same measure. No behavioral differences during the task were predicted because all participants we recruited from the general population and therefore assumed to be unimpaired in their ability to perform the task.

Methods and Materials

Twenty male college students (M = 23.5 years, SD = 4.1 years) were recruited through poster and e-mail advertisements. All participants gave informed consent and completed the Psychopathy Personality Inventory (PPI; Lilienfeld and Andrews 1996) at the start of the study. Scores on the PPI were used to create two subscores based on the work of Benning et al (2003). Each participant's score for emotional–interpersonal function and social deviance was calculated. A median split was then performed to create high and low groups for each subscale. The Committee for the Protection of Human Subjects at Dartmouth College approved all procedures and questionnaires before administration.

Task

Eight adult faces (four men and four women) making four emotional expressions (anger, fear, sad, and joy) were used as stimuli. All pictures were selected from the Montreal Set of Facial Displays of Emotion (Beaupre et al 2000; poster presented at the Conference of La Societe Quebecoise de Recherche en Psycholo-

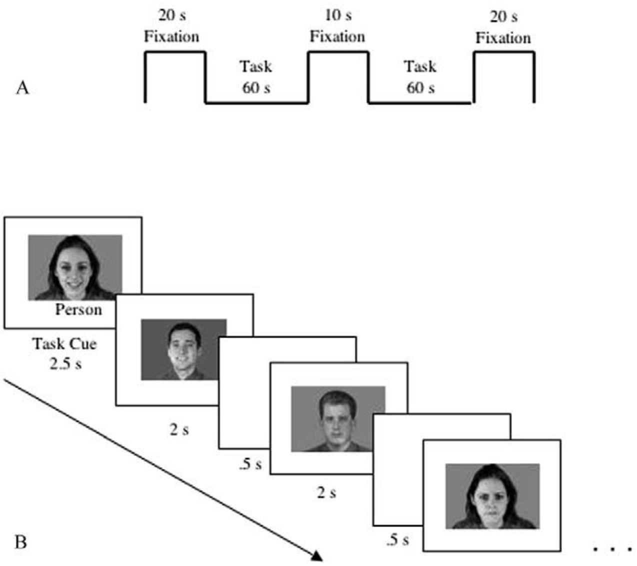

Figure 1. Experimental design. **(A)** Design of a single run. **(B)** Design of a single block. The task cue indicated either the person or the expression as the target of interest.

gie). Stimuli were presented using Psyscope software, and images were back-projected onto a screen via LCD video projector. Subjects viewed the projections via a mirror angled at 45 degrees on top of the head coil. Participants were provided with a target image at the start of each block. They were instructed to press a response button every time the picture they were currently looking at matched the target image on the specified dimension (see Figure 1). During the emotion condition, participants were instructed to match the emotional expression presented. They were told not to focus on the target's gender or identity, but simply the affect presented. In the identity condition, participants' were instructed to match the targets' identity (i.e., "who the person is"), not the emotion presented. Therefore, they were told to press the button every time that individual appeared on their screen, regardless of affect. The same pictures were randomly presented for both conditions. The emotion recognition condition was presented first for all participants because of the known attenuation of amygdala responding with repeated presentation of emotional stimuli (Breiter et al 1996; Whalen et al 1998). The use of the same photographs across both conditions eliminated concern for generalized heightened amygdala responsivity to the emotional faces (Hariri et al 2002). Reaction time and accuracy of responses were collected for each trial. Each run consisted of an initial 20-sec period of rest, followed by two 1-min task blocks separated by a 10-sec rest period and then ending with another 20-sec rest. This functional run was performed twice (once for emotion condition and once for identity condition).

Magnetic Resonance Imaging Acquisition

Magnetic resonance imaging (MRI) data were acquired on a 1.5-Tesla GE Signa System (General Electric, Milwaukee, Wisconsin) equipped with a volume head coil. Foam padding was used to restrict participants' head movement. Structural images were acquired with a T1-weighted sequence and functional images with a gradient echo-planar T2* sequence using BOLD (blood-oxygen level–dependent) contrast. Each functional image comprised 25 noncontiguous slices (4.5 mm thickness, 1 mm gap, 64×64, echo time [TE] = 35 msec, field of view = 24×24 cm) covering the whole brain. In each of two runs, 107 functional volumes were acquired continuously with an effective repetition time (TR) of 2.5 sec. A standard boxcar design was used for the presentation of the task. For each subject, three-dimensional MRI anatomic data were also obtained using the spoiled gradient (SPGR) technique. T1-weighted images (TR = 7.7 msec, TE = 3 msec, flip angle = 15°, slice thickness = 1.2 mm) were obtained in the AC-PC orientation.

Data Analysis

The BOLD data were analyzed using SPM99 software (Wellcome Department of Cognitive Neurology, London, United Kingdom). All scans were realigned, coregistered, and normalized into standard anatomic space (3-mm isotropic voxels) based on the ICBM 152 brain template (Montreal Neurologic Institute), which approximates the Talairach and Tournoux (1988) atlas space. Functional data were then spatially smoothed by a 6-mm FWHM (full-width half-maximum) Gaussian kernel. Individual blocks were modeled by a standard synthetic hemodynamic response function (Friston et al 1995).

A single block type was defined in each run. We used the general linear model to generate parameter estimates of activity at each voxel, for each condition and each subject. No filtering or scaling options were selected. Statistical parametric maps of the t statistic (SPM{t}) generated from linear contrasts between the different conditions and against rest were transformed to a normal distribution (SPM{Z}).

A group analysis was performed using a first- and second-level analysis (i.e., random effects model). For the random effects model, a first-level analysis provided a contrast image for each comparison and each subject. We were interested in the BOLD signal change based on the different task conditions, specifically changes during the emotion and identity conditions relative to the baseline.

In a second-level analysis, the contrast images resulting from the first-level analysis were the basis of a multisubject comparison. Regions of interest were functionally defined by selecting voxels active (relative to baseline) on a samplewise basis during our contrast of interest, the emotion condition. The threshold adopted was $p < .0072$. Changes in mean signal intensity were then extracted for each region of interest, across both conditions, and were compared as a function of group status.

Separate analyses were not performed on each individual emotion (joy, sad, etc.) because emotions were not presented a sufficient number of times to provide confidence in the findings.

Results

Survey

Scores on the complete PPI and each of the two factors (emotional–interpersonal and socially deviant) were calculated. Given the emotion interpretation component of the current task, participants' scores on the first facet were used to determine high versus low scorers among our population. Total scores on the PPI [$t(18) = 3.512$, $p = .002$] and on the emotional–interpersonal factor [$t(18) = 6.005$, $p < .001$] were significantly different between groups. Social deviance total scores did not significantly differ between groups [$t(18) = .427$, $p = ns$]. No differences were found with regard to age (high: $M = 24$ years; low: $M = 23.8$ years), ethnicity (high: 9 responded all Caucasian; low: 9 responded all Caucasian), or socioeconomic status (both groups averaged middle-class status). Because all participants were

Table 1. Identification of Blood Oxygen Level—Dependent Signal Increases for Both Conditions Relative to Baseline *t* Test Valves

Brain Region	x	y	z	High Scorers	Low Scorers
Emotion Condition					
Right 17	21	−93	0	**11.84**[c]	4.02[a]
Right BA 47	39	26	−4	3.59	**5.48**[b]
Medial BA 10	−6	59	19	ns	**4.71**[a]
Right BA 46/9	53	17	41	**8.55**[c]	3.83
Right amygdala	27	5	−18	ns	**2.64**
Identity Condition					
Right 17	21	−93	0	10.32[c]	5.71[a]
Right BA 44/6	39	26	−4	ns	ns
Medial BA 10	−6	59	19	ns	ns
Right BA 46/9	53	17	41	5.32[a]	3.23
Right amygdala	27	5	−18	ns	ns

ns, no detectable signal change associated with condition; BA, Brodmann's area.

p values are corrected for multiple comparisons. Bolded numbers indicate a significant difference between high and low scorers in that region. Coordinates are from Talairach and Tournoux (1988).

[a] $p < .05$.

[b] $p < .01$.

[c] $p < .001$.

students attending the same college, education level was assumed to be equal.

Behavioral

All participants took significantly longer to respond during the emotion condition (M = 1055 msec) than during the identity condition (M = 844 msec; t[18] = 3.728, p = .002). There were no significant reaction time differences (identity: t[18] = .529, p = *ns;* emotion: t[18] = .453, p = *ns*) or significant differences in accuracy (identity: t[18] = .875, p = *ns;* emotion: t[18] = 1.665, p = .118) between high and low scorers in either condition. That is, both groups of participants were equally successful and comparable in time required to complete the tasks.

Neural Correlates

Regions of interest analysis revealed significant differences between high- and low-scoring participants during the emotion condition. Specifically, participants who scored low on the emotional-interpersonal dimension of psychopathy had significantly greater activation in right inferior frontal cortex [t(18) = 2.230, p = .040; 39, 26, −4; all coordinates provided in Talairach and Tournoux (1988) space], right amygdala [t(18) = 2.188, p = .044; 27, 5, −18], and medial prefrontal cortex [t(18) = 5.298, $p <$ .001; −6, 59, 19] than participants who scored high on the this dimension. The high-scoring participants did show significantly greater activation in visual cortex [t(18) = 2.351, p = .032; 21, −93, 0] and right dorsolateral prefrontal cortex [t(18) = 2.5, p = .024; 53, 17, 41]. There were no significant differences between groups in the identity condition for any of these regions. See Table 1 and Figure 2. The distinct cortical pattern of activation measured in the groups indicate that high-scoring participants are relying on regions associated with perception and cognition to do the emotion recognition task, whereas low-scoring participants are taking advantage of regions individually known to be involved in emotion interpretation and response (Damasio et al 1994; LeDoux 1996).

Interestingly, one of these regions was also significantly different when participants were grouped based on their scores on the social deviance dimension of the PPI (Benning et al 2003). The right amygdala showed significantly greater activation in the higher scoring group compared with the low-scoring group only during the emotion recognition condition [t(18) = 2.591, p = .018; 27, 5, −18). There were no significant differences between these groups in the identity condition. Given that we had no a priori hypotheses regarding based on the social deviance factor, no interpretation of these results is offered.

When participants were split by total PPI score, there were again no main differences in the identity condition. One significant difference did emerge in the emotion recognition condition. Medial prefrontal cortex was significantly more active in the participants who scored below the mean on the PPI compared with those who scored above [t(18) = 3.731, p = .109; −6, 59, 19].

Discussion

The present study set out to examine individual differences in neural activity as a function of trait psychopathy. Identical stimuli were used in two tasks, one of which required the processing of

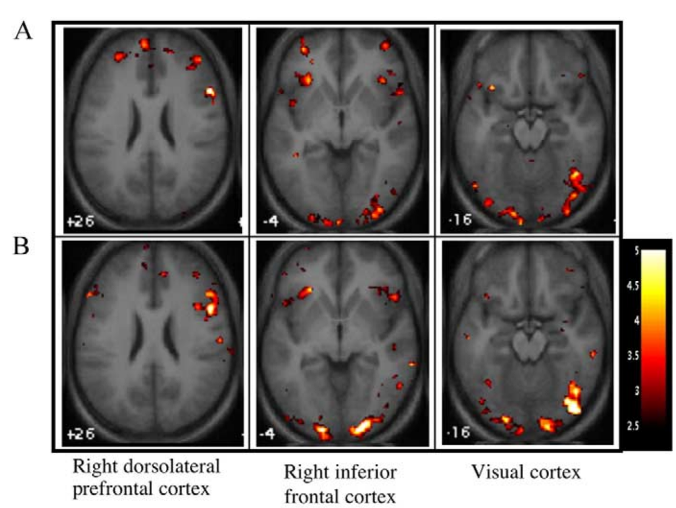

Figure 2. Blood oxygen level–dependent activity during the emotion recognition condition relative to baseline. **(A)** Participants who scored below the mean on the PPI. **(B)** Participants who scored above the mean on the PPI. Pictures presented in neurologic orientation (left side of picture equal to left side of the brain).

emotional information, the other processing of information related to the identity of the stimuli. All participants completed the task with equivalent accuracy and speed regardless of self-reported PPI score, indicating that the differences in functional results were not due to differences in behavioral performance. There were, however, dramatic differences in the cortical areas used to perform the emotion task—differences that were absent in the identity condition. Participants scoring high on the emotional–interpersonal dimension of psychopathy when performing an emotion recognition task used primarily right dorsolateral prefrontal cortex, an area consistently associated with performance on working memory tasks (for a summary, see Fuster 1997), suggesting that these participants maybe relying on cognitive strategies to complete the task. The occurrence of heightened lateral frontal activity in persons relatively higher on a measure of psychopathy parallels work done with clinically tested psychopaths. Multiple studies using verbal emotional stimuli have found increased activation frontally in psychopathic participants when performing emotion tasks (Intrator et al 1997; Kiehl et al 1999). Interestingly, these studies also found that psychopathic participants exhibited similar patterns of activation for both the neutral and emotional words. The fact that the participants did not differ on task speed or accuracy implies that through learning or other forms of compensation, they have acquired alternate strategies to respond appropriately (Intrator et al 1997; Kiehl et al 1999). These skills could help explain why the psychopathic characteristics of high-scoring individuals do not produce clinical or criminal behaviors and is therefore deserving of further investigation.

Those scoring low on the psychopathy measure activated a distributed general emotion network including inferior frontal, medial prefrontal, and amygdala (Adolphs et al 2002; Barrash et al 2000; Fuster 1997). The attenuated amygdala response, seen in those scoring high on the measure of psychopathy, is in line with arguments presented by Blair and colleagues for the integral role the amygdala plays in the manifestation of psychopathic behavior. This work has posited that a malfunctioning amygdala would lead to an inability of fear conditioning and thus increased impulsivity and risk taking (Blair 2001). The relative decreased activity within regions of the prefrontal cortex would suggest that, similar to work by Raine and colleagues (Raine et al 1994, 1998a, 1998b), this area of the brain is involved in the behavioral characteristics and executive functioning differences seen in psychopathy. Arguably, these prefrontal regions and subcortical limbic structures could be working together. It is conceivable that the dysfunction in one of these regions could lead to the manifestation of psychopathy within the normal range, whereas dysfunction of both areas may result in the marked differences in behavior seen in criminal and clinical populations. That is, persons with a hyporesponsive amygdala might show the behavioral problems associated with psychopathy but not the personality-style differences (i.e., manipulativeness, callousness, etc.). Individuals with dysfunction of specific regions prefrontally may manifest behaviors similar to personality or primary psychopaths but not the impulsivity problems. Only with the combined attenuated capabilities of both regions would individuals develop full-blown, clinical psychopathy and most likely demonstrate criminal behavior.

The lack of functional differences between groups during the identity condition is noteworthy for several reasons. First, it implies that the basic visual processing of the stimuli is consistent across participants, and thus the disparities found were not due to perceptual differences. Second, it highlights the similar responding among high-scoring participants between the two conditions. The pattern of activity found in all participants in the identity conditions parallels that seen among only the high-scoring participants in the emotion condition, suggesting that these participants approach the two distinct tasks with a similar strategy.

These results are the first to confirm that persons possessing characteristics in line with psychopathy do, in fact, differ in their neural activation. Little if any comprehensive research has yet been conducted that investigates the behavioral differences between criminal and noncriminal individuals possessing psychopathic traits. The necessity to understand how individuals not influenced by confrontations with and time spent within the judicial system is obvious to those from a variety of fields (Kirkman 2002). The authors recognize, however, that this study possesses certain limitations that would need to be addressed in future research. The use of an all-male population was selected to compare our results with the extensive literature on psychopathy, which almost exclusively focuses on male subjects; there is, however, a need to investigate these differences among female members of the general population. The self-report nature of the PPI is another concern. Psychopathy as a disorder or a personality trait is associated with manipulative and deceitful behavior. Basing participants' relative location along a trait dimension relying on their self-disclosure is of concern; however, these participants are also intelligent and recognize the socially desirable answer for each statement. These combined factors, along with the nonsignificant relation between social desirability and the PPI (i.e., Marlowe-Crowne Social Desirability Scale, see Lilienfeld and Andrews 1996) left us feeling confident in the validity of the measure. Finally, the design of the study prevented examination of responses to specific categories of facial affect. Prior research has indicated that psychopaths show an attenuated ability to label accurately faces that display a negative emotion, specifically disgust, in an emotion-recognition task (Kosson et al 2002). Future work is needed to address the influence of individual emotions on the perception and approach to recognition among the general population.

Collectively, the lack of behavioral differences in the presence of functional differences found within this population are a good indication that more in-depth research into psychopathy as a personality style is feasible within normal populations. It also has implications for researchers interested in emotional interpretation more broadly because the incidence of psychopathy among nonpsychiatric populations has not yet been determined. Therefore, further investigations into the ways in which high-scoring participants interpret and respond to their world is needed. Future research could continue to clarify how the differences in approach strategies toward affective stimuli are selected. The importance of incorporation of knowledge about participants' individual perspectives and approaches is vital to the full understanding of neural activation data (Miller et al 2002).

The capacity for social interaction is highly dependent on the ability to recognize and appropriately respond to affective stimuli. This ability has been consistently identified as an important premorbid factor in many psychiatric disorders. Therefore, the understanding of neural mechanisms underlying affective processing may provide new insights into the early diagnosis and subsequent treatment of psychiatric illness.

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