Prefrontal substrates of empathy: Psychometric evidence in a community sample

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Abstract

Empathy is a vicarious experience of others' emotions, and is crucial to many forms of adaptive social interaction. Clinical, experimental, and functional neuroimaging studies convergently suggest a role for prefrontal-limbic circuits in mediating empathy. This study examined the prefrontal basis of empathy in a community sample using self-report measures: the frontal systems behavior scale (FrSBe), Barratt impulsiveness scale (BIS), and the interpersonal reactivity index (IRI). Multiple correlations emerged supporting an inverse relationship between prefrontal system dysfunction and empathy, particularly emotional empathy and perspective taking. Many of these relationships persisted after controlling for age, sex, and education. However, FrSBe scales did not correlate with one's identification with fictional characters, and motor impulsivity correlated positively, presumably due to the different cognitive and emotional context (i.e. real versus fictional individuals). These studies parallel others using objective methodologies and suggest a graded relationship between prefrontal function and empathy and likely reflect normal variations in prefrontal-limbic function.
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1. Introduction

Empathy is the tendency to vicariously experience others' emotional states (Davis, 1980; Mehrabian and Epstein, 1972). It is a very important aspect of emotion since it motivates both prosocial behavior, appropriate moral development, and discourages antisocial behaviors (Eisenberg, 2000; Litvack-Miller et al., 1997). Empathy is an important component of adaptive interpersonal relationships, and necessary for effective parenting and performance in healthcare professions (Ishii et al., 1997; Becker and Sands, 1988; Kerem et al., 2001). Conversely, empathy is lacking in many individuals who commit crimes such as child abuse, sex offenses, and violent crimes (Fernandez et al., 1999; Rosenstein, 1995; Loper et al., 2001).

There are both cognitive and emotional components of empathy (Davis, 1980; Spinella and Lester, in review). Cognitive components of empathy are akin to "theory of mind," or the ability to mentally represent other peoples' mental processes. This is a form of social cognition, allowing one to appraise another's emotional state, in order to form an emotional reaction in response. Emotional components of empathy involve the actual emotional reaction. Several self-rating scales have been developed to measure empathy. Perhaps, the best-developed scale psychometrically is Davis' interpersonal reactivity index (IRI), which has scales to rate both cognitive and emotional components (Davis, 1980).

Several lines of evidence suggest a role for prefrontal cortex in empathy. Decreases in empathy result from traumatic brain injury that is associated with prefrontal and orbitofrontal hypoactivity (Eslinger, 1998; Varney and Menefee, 1993). A reduction in empathy is particularly seen in neurological insults that disrupt prefrontal-limbic connections (Bardenhagen et al., 1999). Cases of frontotemporal dementia suggest a role for right anterior temporal cortex in empathy. The right anterior temporal cortex is closely associated with orbitofrontal cortex (Perry et al., 2001). Multiple sclerosis has also been associated with reduced empathy, particularly in cases with concurrent executive

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dysfunction (Benedict et al., 2001). Smell identification correlates with empathy in normal, healthy individuals (Spinella, 2002a). However, correlations were only significant with right nostril smell identification, suggesting right orbitofrontal involvement given the predominantly ipsilateral projections of the olfactory system.

Antisocial personality disorder (ASPD) is defined by a constellation of behaviors that stem from a lack of empathy and impulsivity, including manipulation, deceitfulness, aggressiveness, recklessness for the safety of others, irresponsibility, and lack of remorse for one's action upon others (American Psychiatric Association, 2000). The related construct of psychopathy similarly has three underlying factors: deceitful interpersonal style, affective unresponsiveness, and impulsive antisocial behavior (Cooke and Michie, 2001). Several neuropsychological studies indicate that these conditions are associated with prefrontal dysfunction. Individuals with psychopathy have been shown to have deficits on neuropsychological measures sensitive to orbitofrontal cortex (Lapierre et al., 1995; Roussy and Toupin, 2000). However, psychopaths have executive function deficits that are associated with both orbitofrontal and dorsolateral prefrontal cortex (Dolan and Park, 2002). Conduct disorder (CD) is the childhood and adolescent equivalent of ASPD, characterized by aggression, destruction of property, deceitfulness or theft, and disregard for rules (American Psychiatric Association, 2000). There is also a lack of empathy in CD (Frick and Ellis, 1999). Chretien and Persinger (2000) found that executive function deficits correctly classified 89% of juvenile delinquents and controls, even though the two groups were equivalent in estimates of intelligence.

Individuals with ventromedial prefrontal damage are also known to develop a behavioral syndrome termed "acquired sociopathy," which consists of many psychopathy-like behaviors including a reduction in empathy (Barrash et al., 2001; Tranel, 1994; Blair and Cipolotti, 2000; Eslinger et al., 1992). Neuroimaging studies show decreased regional cerebral blood flow (rCBF) in frontotemporal and striatal structures of psychopathic violent offenders that is unrelated to the presence of psychosis, substance abuse, or current medication (Soderstrom et al., 2002). Raine et al. (2000) have shown reduced volume in the prefrontal cortex of individuals with antisocial personality disorder.

A few neuroimaging studies have been done with regard to empathy. A functional magnetic resonance imaging (fMRI) study showed activation in the left superior frontal gyrus and orbitofrontal gyrus during judgements of empathy and forgivability (Farrow et al., 2001). Another study, using positron emission tomography (PET) showed activation in ventromedial prefrontal cortex and superior frontal gyrus during a task that requires judgement of emotion and sympathy, a construct overlapping with empathy (Decety and Chaminade, 2003). Accordingly, activation in the prefrontal-subcortical circuits (orbitofrontal and anterior cingulate cortex, nucleus accumbens, and caudate nucleus) was demonstrated in subjects engaging in social cooperation during the Prisoner's Dilemma Game (Rilling et al., 2002). Both neuroimaging and lesion studies suggest a role for prefrontal cortex, medial prefrontal, and orbitofrontal, in theory of mind ability (Goel et al., 1995; Stone et al., 1998). Collectively, these clinical and experimental studies suggest a role for prefrontal-limbic circuits in empathy, particularly involving orbitofrontal-anterior temporal circuits in the right hemisphere.

Psychometric tests provide a measure of behavior that reflect brain structure and function. While they do not necessarily have anatomical specificity, a few have demonstrated sensitivity to the structure and function of prefrontal regions. For example, go/no-go, antisaccades, delayed alternation, and smell identification are sensitive to orbitofrontal dysfunction, and show several intercorrelations (Spinella, 2002b). Among self-rating scales, responses on the Barratt impulsivity scale (BIS) correlated with the microstructure of white matter in right prefrontal cortex in people with schizophrenia (Hoptman et al., 2002). Horn et al. (2003) showed BIS scores to relate to activation of prefrontal cortex in healthy individuals performing a response inhibition task (go/no-go). BIS scores correlate with errors on go/no-go, antisaccades, and delayed alternation, tasks with demonstrated sensitivity to prefrontal, particularly orbitofrontal dysfunction (Spinella, 2004). The frontal systems behavior scale (FrSBe) has both family/caretaker and self-rating forms that assess behavioral dysfunction associated with prefrontal cortex and associated subcortical structures (e.g. the striatum, mediodorsal thalamus) (Grace and Malloy, 2001). It differentiates people with frontal lesions from those with non-frontal lesions (Grace et al., 1999). The FrSBe can also discriminate between prefrontal behavioral syndromes in people with Alzheimer's disease and Huntington's disease (Paulsen et al., 1996). FrSBe scores also correlate with objective measures of executive dysfunction (Chiaravalloti and DeLuca, 2003; Velligan et al., 2002). Elevated FrSBe scores have been associated with psychoactive drug use which has been associated prefrontal dysfunction in neuroimaging studies (Spinella, 2003; Volkow et al., 1999). FrSBe scores also relate to impulse-control aspects of eating in healthy individuals (Spinella and Lyke, 2004).

This study sought to examine the relationship between standardized, self-rating scales of prefrontal-associated functions and empathy using psychometric measures in normal, healthy individuals.

2. Methods

2.1. Study 1

2.1.1. Participants

The participants ($N = 101$; 50 females, 51 males) were a convenience sample of healthy, community-dwelling individuals. They were voluntarily recruited by research

assistants from the local community surrounding the college campus. No specific selection criteria were given other than to find non-institutionalized, community-dwelling adults. Participants did not receive any financial compensation for their participation. Participants ranged in age from 14 to 57 years ($M = 27.0$, S.D. = 11.2) and had completed between 8 and 18 years of education ($M = 14.0$, S.D. = 2.3).

2.1.2. Measures

2.1.2.1. Frontal systems behavior scale (FrSBe).
The FrSBe is an instrument that measures neurobehavioral traits associated with regions of the prefrontal cortex (Grace et al., 1999). It is a self-rating scale of 46 items, which yields scores for three scales of dysfunction: apathy (A, e.g. "I sit around doing nothing."), disinhibition (D, e.g. "I do risky things just for the heck of it."), and executive dysfunction (E, e.g. "I mix up a sequence, get confused when doing several things in a row."). These scales were designed to measure neurobehavioral syndromes associated with medial prefrontal, orbitofrontal, and dorsolateral prefrontal cortex, respectively. An adaptation of the FrSBe was needed to measure prefrontal-associated traits in this study: whereas the original version was designed for clinical populations and asks for pre- and post-injury/illness ratings for each item, participants in this study were only asked for one global self-rating per item. The normative data for the instrument indicate that all scales of the FrSBe have been noted to vary with age, sex, and level of education.

Reliability studies of the FrSBe have shown high intrascale reliability in normal and clinical samples, and factor analytic data support the validity of the three scales (Grace et al., 1999; Grace and Malloy, 2001). Validity of the instrument is further supported by three lines of evidence: (1) people with frontal lobe injuries have higher scores compared to their pre-injury status, (2) people with frontal lobe injuries score higher than healthy controls, and (3) people with frontal lobe injuries score higher than those with non-frontal injuries. The instrument has also shown validity in psychiatric and dementia populations. The FrSBe total scores (combining the three subscales) ranged from 64 to 154 in this sample ($M = 103.4$, S.D. = 21.0) (Table 1). This is generally consistent with the data reported by Grace and Malloy (2001), who stratify their normative sample by age, sex, and education (Table 2). Due to the smaller sample size used here, it would not be possible to stratify in the manner done with the normative sample. Further, the normative sample scores may be somewhat lower: their participants were screened for any history of neurological, psychiatric, and substance abuse disorders, as well as for current use of any psychotropic medications.

2.1.2.2. Interpersonal reactivity index.
The IRI is a 28-item self-report scale designed to measure both cognitive and emotional components of empathy (Davis, 1980). The subscales of the IRI were arrived at by factor analysis and consist of perspective taking (IRIpt), fantasy scale (IRIfs),

Table 1
Descriptive statistics for the frontal system behavior scale (FrSBe) and interpersonal reactivity index (IRI) scales in the sample for Study 1

	Females			Males		
	Range	M	S.D.	Range	M	S.D.
FrSBe A	16–43	28.9	6.1	20–51	32.6	7.4
FrSBe D	19–47	30.8	7.5	20–53	36.6	7.7
FrSBe E	21–59	35.7	8.9	26–66	42.0	9.3
IRIpt	4–27	17.5	4.7	0–25	14.0	5.4
IRIfs	3–28	17.2	5.9	0–26	13.8	6.2
IRIec	11–28	20.9	4.9	1–26	16.3	5.2
IRIpd	0–20	10.8	5.1	0–21	10.8	6.1

Abbreviations: A, apathy; D, disinhibition; E, executive dysfunction; IRIpt, perspective taking; IRIfs, fantasy; IRIec, empathic; IRIpd, personal distress.

empathic concern (IRIec), and personal distress (IRIpd). Items of the IRIpt scale address one's tendency to take another's point-of-view, akin to the "theory of mind" (e.g. "When I am upset at someone, I usually try to 'put myself in his shoes' for a while.") IRIfs scale items address the tendency to identify with fictional characters (e.g. "I really get involved with the feelings of the characters in a novel."). IRIec items relate to feelings of empathy towards others (e.g. "When I see someone being taken advantage of, I feel kind of protective towards them."), while IRIpd addresses the tendency to experience distress in stressful situations (e.g. "In emergency situations, I feel apprehensive and ill-at-ease."). The IRI has demonstrated good intrascale and test–retest reliability, and convergent validity is indicated by correlations with other established empathy scales (Davis, 1980). See Table 2 for means and standard deviations of scores derived from the IRI standardization sample (Davis, personal communication). Davis' sample was comprised of male and female undergraduate students in an introductory psychology class. Despite the difference in samples (community sample versus college students), the IRI scores are generally comparable.

2.1.3. Results

Pearson correlations with two-tailed significance showed several significant relationships between FrSBe and IRI

Table 2
Reported normative data for the frontal system behavior scale (FrSBe) and interpersonal reactivity index (IRI) (Davis, personal communication; Grace and Malloy, 2001)

	Females		Males	
	M	S.D.	M	S.D.
FrSBeT[a]	87.3	22.7	93.9	11.8
FrSBeT[b]	78.1	15.8	86.2	15.2
IRIpt	17.96	4.85	16.78	4.72
IRIfs	18.75	5.17	15.73	5.60
IRIec	21.67	3.83	19.04	4.21
IRIpd	12.28	5.01	9.46	4.55

Abbreviations: IRIpt, perspective taking; IRIfs, fantasy; IRIec, empathic; IRIpd, personal distress; FrSBeT[a], FrSBE total scores of individuals with ≤12 years of education; FrSBeT[b], FrSBE total scores of individuals with ≥12 years of education.

Table 3
Correlations between frontal system behavior scale (FrSBe) and interpersonal reactivity index (IRI) subscales

	Bivariate			Partial		
	A	D	E	A	D	E
IRIpt	−.24[*]	−.24[*]	−.30[†]	−.16	−.15	−.21[*]
IRIfs	.00	.04	−.13	.10	.12	−.04
IRIec	−.32[‡]	−.28[†]	−.38[‡]	−.24[*]	−.14	−.28[†]
IRIpd	.30[†]	.19	.31[†]	.31[†]	.13	.32[‡]

($N = 101$, two-tailed significance). Partial correlations are controlling for age, sex, and education (d.f. = 96). *Abbreviations*: A, apathy; D, disinhibition; E, executive dysfunction; IRIpt, perspective taking; IRIfs, fantasy; IRIec, empathic; IRIpd, personal distress.

[*] $p < = .05$.
[†] $p < = .01$.
[‡] $p < = .001$.

scores (Table 3). Inverse relationships emerged between two IRI scales (IRIpt and IRIec) and all three FrSBe subscales. There was no relationship between IRIfs and FrSBe scales, and IRIpd showed positive relationships with A and E. Partial correlations were performed controlling for the influences of age, sex, and education. Some correlations were diminished in magnitude, but many remained significant and in the same direction after removing demographic influences. IRIpt correlated inversely with E, IRIec correlated inversely with A and E, and IRIpd correlated positively with A and E (Fig. 1).

In this sample, four males and eight females scored two standard deviations or more above the mean, indicating the possibility of clinically significant impairment. As discussed above, this was a community sample that was not screened for neuropsychiatric illnesses, so it is likely that some individuals participating would have some form of disorder. Common conditions such as substance abuse or attention deficit-hyperactive disorder would elevate scores on the FrSBe.

2.2. Study 2

2.2.1. Subjects

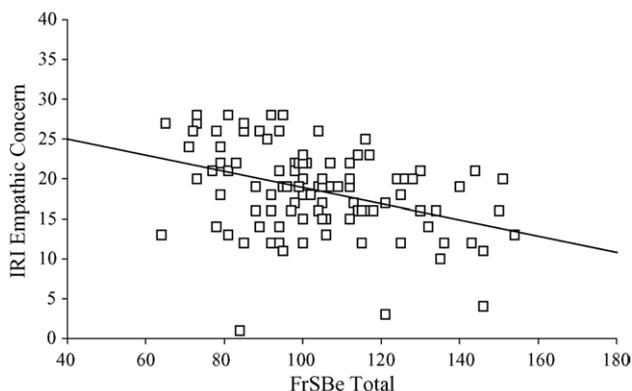The subjects were a separate convenience sample of healthy, community-dwelling individuals recruited by

Fig. 1. Scatter plot of FrSBe total score and empathic concern.

Table 4
Descriptive statistics for the Barratt impulsiveness scale (BIS) and interpersonal reactivity index (IRI) scales in the sample for Study 2

	Females			Males		
	Range	M	S.D.	Range	M	S.D.
BISnp	13–41	24.9	5.1	17–33	26.5	3.6
BISm	14–37	22.7	4.6	12–31	22.4	4.2
BISa	11–30	18.7	4.0	13–32	20.4	3.6
IRIpt	0–28	17.4	4.3	0–28	17.4	4.3
IRIfs	1–28	12.9	5.4	1–28	12.9	5.4
IRIec	8–28	19.8	4.3	8–28	19.8	4.3
IRIpd	2–25	10.3	4.4	2–25	10.3	4.4

research assistants. The study was approved by an institutional review board and all subjects read and agreed to appropriate implied consent form. They did not receive any financial compensation for their participation. Ninety-eight subjects participated (49 female, 49 male), ranging in age from 16 to 57 ($M = 26.2$, S.D. = 10.4) years and achieving between 8 and 18 years of education ($M = 13.9$, S.D. = 2.2).

2.2.2. Measures

The IRI was administered again in this study. Descriptive statistics for the IRI and BIS are reported in Table 4.

2.2.2.1. Barratt impulsiveness scale–version 11 (BIS). The BIS is a 30-item, self-rating scale, which measures three factors: non-planning (orientation toward the present rather than the future, BISnp), motor impulsivity (or acting without thinking, BISm), and attentional impulsivity (e.g. lack of concentration, BISa) (Patton et al., 1995). Representative items include: ''I plan tasks carefully'' (BISnp, inverted item), ''I act on impulse'' (BISm), and ''I concentrate easily'' (BISa, inverted item). The BIS has good psychometric properties and validity established in psychiatric and forensic populations. Two neuroimaging studies have demonstrated sensitivity of the BIS to prefrontal function. Normative data have not yet been reported for the BIS.

2.2.3. Results

Pearson correlations were obtained between scales of the BIS and IRI (Table 5). Inverse correlations were found between IRI subscales (IRIpt and IRIec) with BIS subscales (BISnp and BISa). BISnp also correlated inversely with IRIfs, but BISm, however, correlated positively with IRIfs. After removing demographic influences with partial correlations, correlations between IRIpt, IRIec, and BISnp remained significant. The BISm correlation with IRIfs also remained significant.

3. Discussion

The pattern of correlations observed here is consistent with prefrontal dysfunction in relation to empathy.

Table 5
Correlations between the Barratt impulsiveness scale (BIS) and interpersonal reactivity index (IRI) subscales

	Bivariate			Partial		
	BISnp	BISm	BISa	BISnp	BISm	BISa
IRIpt	−0.39[‡]	0.03	−0.23[*]	−0.35[‡]	0.03	−0.15
IRIfs	−0.21[*]	0.26[†]	−0.16	−0.19	0.26[†]	−0.14
IRIec	−0.30[†]	0.01	−0.20[*]	−0.25[*]	0.01	−0.09
IRIpd	0.04	0.19	0.17	0.00	0.17	0.13

($N = 99$, two-tailed significance). Partial correlations are controlling for age, sex, and education (d.f. = 93). *Abbreviations*: BISnp, nonplanning; BISm, motor impulsivity; BISa, attention impulsivity; IRIpt, perspective taking; IRIfs, fantasy; IRIec, empathic; IRIpd, personal distress.

[*] $p < = .05$.
[†] $p < = .01$.
[‡] $p < = .001$.

Perspective taking (IRIpt) correlated inversely with apathy, disinhibition, executive dysfunction, nonplanning, and inattention. Emotional empathy (IRIec) similarly correlated inversely with all FrSBe scales and with nonplanning and inattention. These indicate a clear reduced tendency to think and feel from another person's perspective in associated with characteristics of prefrontal dysfunction. Many of these relationships persisted after controlling for demographic influences.

The inverse correlations with IRIpt suggest a possible deficit of theory of mind associated with antisocial behavior. A theory of mind impairment is not one of the diagnostic criterion for ASPD, but it is possible that it may be an associated feature in a subgroup of the population. Indeed, a lack of empathy could result from poor comprehension of social cues and/or lack of emotional reaction to perceived social cues. In support of this, a case of frontotemporal dementia has been reported with severe antisocial behavior and poor performance on a theory of mind task, but otherwise preserved executive functioning (Lough et al., 2001). Similarly, both neuroimaging and lesion studies suggest a role for medial prefrontal and orbitofrontal cortex in theory of mind ability (Goel et al., 1995; Stone et al., 1998). IRIpt items do not purely address theory of mind, however; they also have an empathic element. For example, the item "When I am upset at someone, I usually try to 'put myself in his shoes' for a while," exemplifies a prosocial willingness to understand other's perspective and resolve conflicts. This would be antithetical to antisocial tendencies. However, since the IRIpt scale has both empathic elements in many of its items, it could not be determined if the relationships observed here are due simply to reductions in empathy or also due to an inability to mentally represents another's thoughts.

Personal distress (IRIpd) correlated positively with FrSBe scales (A and E). Correlations with BIS subscales were also positive but did not reach significance. While both IRIec and IRIpd measure emotional aspects of empathy, the IRIpd scale items carry more of an emotional dysregulation component; the items all center around an inability to effectively manage one's distress in difficult situations, resulting in tension, anxiety, and a feeling of loss of control. Thus, it is not surprising that this scale relates positively to prefrontal dysfunction. Indeed, prefrontal-limbic interactions have been associated with emotional regulation and dysfunction of this circuit results in poor anxiety management (Davidson, 2002).

None of the FrSBe scales correlated with the fantasy scale (IRIfs), and motor impulsivity (BISm) correlated positively with it. The fantasy subscale measures one's tendency to correlate with fictional characters. While this is a form of vicarious emotional experience, it does not carry the same cognitive meaning or emotional impact as reactions to people in real-life situations. It seems, therefore, that the relation between prefrontal dysfunction and empathy relates specifically to real-life situations is not a reflection of a non-specific emotional reaction. Motor impulsivity, on the other hand, showed a positive correlation with IRIfs. The FrSBE and BIS address related but not identical constructs, where the FrBSe samples a wider variety of prefrontal-associated traits. The BISm items are restricted to acting without forethought, so the association here may represent an impulsive tendency for one to be drawn into an appealing story line. In contrast, neither perspective taking (IRIpt) nor emotional empathy (IRIec) bore any relationship to motor impulsivity.

A primary limitation of these studies is the self-rating methodology. This does not allow for functional localization of the traits examined here. However, the BIS and FrSBe have been validated as measures sensitive to prefrontal dysfunction, and, as such, the results are consistent with prefrontal substrates for empathy. Together with existing studies utilizing neurological populations and functional neuroimaging, this study provides convergent evidence utilizing different methodology. Each method of research in the behavioral neuroscience has its strengths and limitations. When used in combination, they can provide convergent evidence that transcends particular methodologies.

Another potential limitation of the study is that the willingness of those approached to participate could relate to their level of empathy, i.e. some with lower levels of empathy may have declined to participate. However, the samples collected here approximate those reported by Davis (1980). Further, the scores obtained range from high to low, also based on Davis' sample. It appears that the range of scores obtained here was sufficient to demonstrate a range of responses. However, results may be somewhat different in segments of the population that were not reached in this sample, such as institutionalized forensic or clinical populations.

The FrSBe subscales were developed to characterize neurobehavioral syndromes produced by regional damage to prefrontal-subcortical circuits (medial prefrontal, orbitofrontal, and dorsolateral), but these scales may or may not measure the function of those discrete regions. Alternatively, they may assess traits that involve overlapping and

widespread regions of prefrontal systems. Since all three FrSBe scales tended to correlate with the IRI subscales, it could indicate that multiple prefrontal regions are involved in those functions in some respect, or it could indicate a lack of anatomical specificity of the subscales. Medial prefrontal cortex has not been particularly associated with empathy in most studies. However, Raine et al. (1994) did find medial prefrontal hypometabolism in murderers. Further work with neuroimaging or brain injured samples may shed light on this issue.

In sum, these studies found correlations between aspects of empathy and traits associated with prefrontal dysfunction. The directionality of these findings are meaningful and consistent with those found in clinical and functional neuroimaging studies. Further, these relationships are not simply due to demographic variations. These studies extend the findings of clinical lesion studies relating empathy to prefrontal function into the normal population. Many of the behaviors and traits observed in neuropsychiatric illnesses represent extreme variations of ordinary behaviors. Associations of deficient empathy and prefrontal dysfunction are more evident in more extreme cases, such clinically- or forensically-relevant cases of ASPD, CD, or neurological injury. However, this study demonstrates that these traits are continuously related to one another, which may represent a normal distribution of personality traits and prefrontal-limbic function in the population. However, functions mediated by prefrontal systems are normally distributed throughout the population and subtle variations in structure and function produce individual differences in behavior and personality.

Acknowledgement

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