Volume Reduction in Prefrontal Gray Matter in Unsuccessful Criminal Psychopaths

Yaling Yang, Adrian Raine, Todd Lencz, Susan Bihrle, Lori LaCasse, and Patrick Colletti

Background: *Although studies of neurologic patients have suggested that prefrontal structural impairments may predispose to sociopathy, it is unknown whether there is a relationship between psychopathy and prefrontal volume in individuals from the community and whether any prefrontal structural impairment is specific to "unsuccessful" (caught) psychopaths as opposed to "successful" (uncaught) psychopaths. This study tests the hypothesis that psychopathy is associated with a reduction in prefrontal gray volume but that this abnormality is specific to unsuccessful psychopaths.*

Method: *Prefrontal gray and white matter volumes were assessed using structural magnetic resonance imaging (MRI) in 16 unsuccessful psychopaths, 13 successful psychopaths, and 23 control subjects.*

Results: *Higher total as well as subfactor psychopathy scores (arrogant/deceptive, affective, and impulsive/unstable) were all associated with low prefrontal gray volume. Unsuccessful psychopaths, but not successful psychopaths, had a 22.3% reduction in prefrontal gray matter volume compared with control subjects.*

Conclusions: *These results demonstrating for the first time a prefrontal structural deficit in community psychopaths provide partial support for a prefrontal theory of psychopathy but highlight an important difference between successful and unsuccessful psychopaths.*

Key Words: Affective, antisocial, impulsive, MRI, prefrontal, psychopathy

For more than 150 years, it has been speculated that damage to the prefrontal cortex can give rise to pseudo-psychopathic behavior (Damasio 1994; Damasio et al 1990). The somatic marker hypothesis suggests that prefrontal damage results in poor decision making, reduced autonomic functioning, and a psychopathic-like personality (Damasio 1994). Neurologic studies have demonstrated that patients who had suffered major damage to the gray and white matter of the prefrontal cortex acquire a psychopathic-like personality (Damasio et al 1990). Several initial studies have shown a relationship between antisocial and aggressive personality and prefrontal gray volume reduction (Laakso et al 2002; Raine et al 2000), although this finding is not universal (Dolan et al 2002). In addition, one meta-analysis has argued for prefrontal (executive) functional impairments in psychopaths (Morgan and Lilienfeld 2000). Surprisingly, however, few structural brain imaging studies have been conducted on psychopathy. Consequently, an important but unanswered question in the field concerns whether psychopathic individuals show a structural impairment to the prefrontal cortex.

Three basic questions on the relationship between prefrontal volume and psychopathy can be posed. First, do individual differences in psychopathy correlate with the volume of prefrontal gray and white matter in a community sample? Given prior research on neurologic patients (Damasio 1994), it would be expected that higher psychopathy scores would be associated with lower prefrontal volume. Furthermore, is the volume reduction specific to gray matter, white matter, or both? Neurologic research has implicated destruction of both prefrontal gray and white in predisposing to sociopathy (Damasio 1994), but the three prior magnetic resonance imaging (MRI) studies of antisocial populations have failed to observe prefrontal white matter volume reductions (Dolan et al 2002; Laakso et al 2002; Raine et al 2000). The impairment in psychopathy may not be connectivity per se (i.e., white matter loss) but instead compromised neuronal integrity that predisposes to disinhibited behavior.

A second basic question concerns whether any correlation between psychopathy and prefrontal gray volume is specific to certain subfeatures of psychopathy. Hare (1991) has suggested that two factors (factor 1: affective/interpersonal; factor 2: antisocial lifestyle) underlie psychopathy. More recently, another delineation proposed by Cooke and Michie (1999, 2001) separates psychopathy into three subtypes: factor 1 (arrogant/deceptive), factor 2 (affective), and factor 3 (impulsive/unstable). Because patients with prefrontal damage have deficits in autonomic and central nervous system functioning that contribute to impulsive, rule-breaking, reckless, irresponsible behavior (Bechara et al 1997; Fuster 2003) as well as affective impairments (e.g., poor fear conditioning; Patrick et al 1997; Raine et al 1993), it could be hypothesized that the link between various factors of psychopathy and prefrontal gray volume may only hold for Cooke's factors 2 (affective) and 3 (impulsive/unstable), but not factor 1 (arrogant/deceptive). Alternatively, the link between prefrontal gray volume and subfeatures of psychopathy may instead be general and nonspecific.

A third question concerns whether any prefrontal structural impairment is specific to "unsuccessful" psychopaths. One initial study indicated that unsuccessful psychopaths show reduced autonomic stress reactivity and executive function deficits compared with control subjects (Ishikawa et al 2001). Successful psychopaths, in contrast, showed heightened autonomic stress reactivity and better Wisconsin Card Sorting Test (WCST) performance than unsuccessful psychopaths and control subjects. Because both autonomic functional and executive functional deficits result from structural damage to the prefrontal cortex (Bechara et al 1997; Damasio 1994; Fuster 2003), these initial studies would lead to the prediction that unsuccessful, but not successful, psychopaths would show prefrontal structural impairments. Similarly, the only structural brain imaging study on psychopaths to date has showed an exaggerated structural

From the Department of Psychology (YY, AR, SB, LL), University of Southern California, Los Angeles, California; Department of Research (TL), Hillside Hospital (North Shore–Long Island Jewish Health System), Glen Oaks, New York; and Department of Radiology (PC), University of Southern California School of Medicine, Los Angeles, California.

Address reprint requests to Adrian Raine, Department of Psychology, University of Southern California, Los Angeles, CA 90089-1061; E-mail: raine@usc.edu.

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anterior hippocampal asymmetry (right > left) in unsuccessful psychopaths compared with both successful psychopaths and control subjects (Raine et al 2004), again suggesting that brain structural impairments are specific to unsuccessful forms of psychopathy.

In this study, we attempt to address these three research questions by assessing prefrontal volume and psychopathy within a community sample. Prefrontal gray and white matter volumes were segmented separately to assess specificity of any deficit to gray matter. It was predicted that high psychopathy would be associated with reduced prefrontal gray volume, but that this volume reduction would be specific to unsuccessful psychopaths.

Method and Materials

Subjects

All subjects were drawn from a total sample of 108 community volunteers drawn from five temporary employment agencies in Los Angeles (Raine et al 2000); 91 men were recruited into the study of whom 84 received a structural MRI scan. Group classification was based on total scores on the Psychopathy Checklist—Revised (PCL-R; Hare 1991, described later), as well as a history of criminal convictions derived from statewide court records and lifetime self-reports (Ishikawa et al 2001). Based on a neuroradiologic screen conducted blind to group membership and before image analysis, one participant was a priori excluded from the study because of major atrophy to the right superior temporal gyrus (Raine et al 2000). Written informed consent was obtained from all subjects and procedures approved by the Internal Review Board at the University of Southern California.

In line with previous reports on this same sample (for details, see Ishikawa et al 2001; Raine et al 2004), successful psychopaths were defined as those with high psychopathy scores (≥ 23) who escaped detection for their crimes, whereas "unsuccessful" psychopaths had high psychopathy scores but were detected and convicted for their criminal acts. The final samples consisted of 13 successful psychopaths with no convictions, 16 unsuccessful psychopaths, and 23 control subjects. These three groups constituted a total sample of 52 individuals. "Success" here refers strictly to evading detection for crimes and does not imply success in occupational or other psychosocial contexts.

Psychopathy and Crime Assessment

Psychopathy was assessed using the Psychopathy Checklist—Revised (PCL-R), and supplemented by five sources of collateral data (Ishikawa et al 2001). The PCL-R consists of 20 items, which yield both a total score and factor scores for either a two-factor solution (affective/interpersonal and antisocial lifestyle; Hare 1991) or three factors (arrogant/deceptive, affective, and impulsive/unstable; Cooke and Mitchie 2001). PCL-R ratings were made by a clinical doctoral student trained and supervised by the second author (AR). The five collateral sources for assessing psychopathy were 1) the Interpersonal Measure of Psychopathy (Kosson 1997), which provides an interviewer's ratings of the participant's interpersonal behaviors and which has been validated for use with incarcerated and nonincarcerated samples; 2) self-reported crime as assessed by an adult extension (Raine et al 2000) of the National Youth Survey self-report delinquency measure (Elliott et al 1983); 3) official criminal records; and 4) data derived from and behavioral observations made during the Structured Clinical Interview for the DSM-IV Mental Disorders (SCID I; First et al 1995a) and (5) the SCID Axis II Personality Disorders (SCID II; First et al 1995b).

To help minimize denial of self-report crime by truly criminal offenders, a certificate of confidentiality was obtained from the Secretary of Health and Human Services. Under section 303 (a) of the Public Health Act 42, the research investigators were protected from being subpoenaed by any federal, state, or local court in the United States to release the self-report crime data.

Diagnostic, Cognitive, and Demographic Assessments

The SCID I and II were administered by a clinical doctoral student who received systemized training in SCID assessment that included reliability checks with expert raters (Ventura et al 1998). Five subtests of the Wechsler Adult Intelligence Scale—Revised (Wechsler 1981) were used to estimate full scale IQ (vocabulary, arithmetic, digit span, digit symbol, block design). Degree of right- versus left-hand preference was assessed using the abbreviated Oldfield Inventory (Bryden 1977), with high scores indicating a stronger preference for right-handedness. A lifetime diagnosis of drug and alcohol abuse or dependence was assessed using the SCID. History of head injury was defined as head trauma resulting in hospitalization. Social class was measured using the Hollingshead (1975) classification system. Details of group scores on psychiatric, cognitive, and demographic measures together with group comparisons are given in Table 1.

MRI Acquisition and Image Analysis

Structural MRIs were conducted on a Philips (S15/ACS) scanner with a magnet of 1.5-Tesla field strength. Following an initial alignment sequence of one midsaggital and four parasagittal scans (spin-echo T1-weighted image acquisition, repetition time [TR] = 600 msec, echo time [TE] = 20 msec) to identify the anterior-posterior commissure (AC-PC) plane, 128 three-dimensional (3D) T1-weighted gradient-echo coronal images (TR = 34 msec, TE = 12.4 msec, flip angle 35°, 1.7 mm thickness, 256 × 256 matrix, field of view = 23 cm) were taken in the plane directly orthogonal to the AC-PC line.

Brain images were reconstructed in 3D using a SPARC workstation and semiautomated CAMRA S200 ALLEGRO software used for gray/white/cerebrospinal-fluid segmentation. The prefrontal region was defined as all cortex anterior to the genu of the corpus callosum and divided into left and right hemispheres along the longitudinal fissure. Segmentation of gray and white matter was performed using a thresholding algorithm, with the operator blind to group membership applying a cutoff value to the signal intensity histogram to optimally differentiate white from gray, areas of which were defined using an automated seeding algorithm on each slice (see Raine et al 2000). Whole brain volume was defined as all cerebral cortex excluding the ventricles, pons, and cerebellum. The pons was excluded by drawing a straight line between the two innermost points that form the superior border. Colliculi were excluded when no longer attached to the cerebral hemispheres.

For volume measures, areas on each slice (mm^2) were multiplied by slice thickness (1.7 mm) and summated to provide volumes in cm^3. Interrater reliability (intraclass correlation coefficient) based on 23 scans (raters blind to each other's ratings and group membership) were as follows: total brain volume (.99), left prefrontal gray (.99), right prefrontal gray (.99), left prefrontal white (.93), right prefrontal white (.94), and total brain volume (.99). All prefrontal volumes were corrected for whole brain volume.

Table 1. Demographic, Cognitive, Diagnostic, and Criminal Measures on the Three Groups

	UP (n = 16)		SP (n = 13)		C (n = 23)		Statistics	Group Comparisons[a]
Age, M (SD)	33.81 (6.62)		29.62 (6.13)		28.35 (6.63)		$F(2,49) = 3.43, p = .04$	C < UP
SES, M (SD)	31.81 (7.40)		30.62 (10.20)		37.36 (10.54)		$F(2,48) = 2.61, p = .084$	
Ethnicity, white/other	5/11		7/6		14/9		$\chi^2(2,51) = 3.32, p = .19$	
IQ, M (SD)	96.44 (14.69)		99.08 (14.23)		105.09 (16.93)		$F(2,48) = 1.54, p = .23$	
Head Injury (n)	6		8		6		$\chi^2(2,50) = 5.08, p = .08$	C < SP
Head Circumference, M (SD)	57.73 (1.84)		58.04 (1.65)		57.38 (1.58)		$F(2,48) = 2.61, p = .54$	
Handedness, R/L	13/3		13/0		17/6		$\chi^2(2,51) = 3.44, p = .18$	
Diagnostic and Criminal Psychopathy								
Total, M (SD)	30.06 (5.34)		26.31 (2.56)		10.85 (2.84)		$F(2,52) = 158.68, p = .0001$	C < SP < UP
Range	23–40		23–31		2–14			
Hare's Factor 1, M (SD)	11.25 (3.19)		10.85 (1.95)		3.35 (1.98)		$F(2,52) = 71.78, p = .0001$	C < SP, UP
Range	7–16		8–15		1–7			
Hare's Factor 2, M (SD)	13.88 (2.87)		11.00 (1.91)		5.23 (2.05)		$F(2,52) = 76.46, p = .0001$	C < SP < UP
Range	9–18		8–16		0–9			
Cooke's Factor 1, M (SD)	5.94 (1.57)		5.23 (1.17)		1.88 (1.42)		$F(2,52) = 48.78, p = .0001$	C < SP, UP
Range	3–8		3–7		0–5			
Cooke's Factor 2, M (SD)	5.31 (1.96)		5.62 (1.33)		1.46 (1.14)		$F(2,52) = 51.20, p = .0001$	C < SP, UP
Range	2–8		4–8		0–4			
Cooke's Factor 3, M (SD)	7.44 (2.10)		7.08 (1.32)		3.54 (2.08)		$F(2,52) = 25.61, p = .0001$	C < SP, UP
Range	3–10		5–10		0–7			
Drug or Alcohol Abuse/Dependence (n)	14		9		7		$\chi^2(2,48) = 23.0, p = .0001$	C < SP, UP
	M	SD	M	SD	M	SD		
Time Drink Alcohol/Month	4.31	5.30	8.00	7.80	3.92	6.16	$F(2,51) = 1.9, p = .16$	
Court Convictions								
Total	4.06	5.09	—	—	—	—	$F(2, 52) = 12.52, p = .0001$	SP, C < UP
Violent Crime	0.5	0.89	—	—	—	—	$F(2, 52) = 6.15, p = .004$	SP, C < UP
Nonviolent Crime	3.56	4.56	—	—	—	—	$F(2, 52) = 12, p = .0001$	SP, C < UP

C, control subject; L, left; R, right; SES, socioeconomic class; SP, successful psychopath; UP, unsuccessful psychopath.
[a]All group comparisons are two-tailed, $p < .05$.

Data Analysis

All analyses were conducted using SPSS (SPSS, Chicago, Illinois). First, to assess the first two questions regarding individual differences in psychopathy and prefrontal volume, we conducted correlation analyses on the combined sample of 52 individuals. To answer the third question regarding successful versus unsuccesful psychopathy, we conducted one-way analysis of variance followed up by planned contrasts using t tests. All tests of significance are two-tailed with an α level of .05.

Results

Correlational Analyses

Correlations between psychopathy scores and prefrontal volumes (n = 52) are shown in Table 2. For corrected prefrontal volumes, analyses showed that high total PCL-R scores are associated with low prefrontal gray matter volumes ($r = -.388$, $p = .004$). Very similar correlations were found for Hare's factor 1 ($r = -.370$, $p = .007$) and factor 2 ($r = -.355$, $p = .01$). Furthermore, all the three Cooke factors again showed similar relationships with prefrontal gray volume: Cooke's factor 1 ($r = -.320$, $p = .02$), Cooke's factor 2 ($r = -.372$, $p = .007$), Cooke's factor 3 ($r = -.286$, $p = .04$), and Cooke's factor 4 ($r = -.361$, $p = .009$). Almost identical results were found for absolute prefrontal gray volumes (see Table 2). In contrast, no such correlations were observed for prefrontal white matter or whole brain volumes, with the sole exception of one correlation associating high scores on Cooke's arrogant/deceptive factor 1 and increased prefrontal/whole brain white matter.

Unsuccessful and Successful Psychopaths

Unsuccessful psychopaths showed a significant reduction in prefrontal gray matter volume (Figure 1). A one-way analysis of variance (ANOVA) on whole-brain corrected total prefrontal gray matter showed a significant group effect [$F(2,49) = 7.794$, $p = .001$, eta^2 = .24]. Planned contrasts showed that unsuccessful psychopaths had a lower prefrontal gray matter/whole brain volume (M = .073, SD = .012) compared with both control subjects (M = .090, SD = .012, $t = 4.03$, $df = 37$, $p = .0001$) and successful psychopaths (M = .086, SD = .014, $t = 2.49$, $df = 27$, $p = .019$). Control subjects and successful psychopaths did not differ significantly ($p = .38$). The same effects were observed for uncorrected prefrontal gray volume [$F(2,49) = 5.76$, $p = .006$]. In contrast, groups did not differ on prefrontal white matter volumes [$F(2,49) = 1.28$, $p = .29$].

Potential Confounds

Groups differed significantly on age, substance and alcohol use, and history of head injury; a trend ($p < .10$) for socioeconomic status was shown as well. To rule out these potential confounds, they were included as covariates in the one-way ANOVAs. Group differences in prefrontal gray volumes remained significant after correcting for age [$F(2,48) = 5.31$, $p = .008$], drug and alcohol abuse/dependence [$F(2,47) = 6.10$, $p = .004$], history of head injury [$F(2, 47) = 7.20$, $p = .002$], and socioeconomic status [$F(2, 47) = 7.48$, $p = .002$].

It could be speculated that the prefrontal gray volume reduction in unsuccessful psychopaths might simply be accounted for by increased antisociality in this group. To test this possibility,

Table 2. Intercorrelations Between Prefrontal Gray and White Matter Volumes and Psychopathy Scores in the Total Sample ($N = 52$)

	Prefrontal Gray Volume		Prefrontal White Volume	
	Prefrontal Gray/ Whole Brain	Absolute Prefrontal Gray Volume	Prefrontal White/ Whole Brain	Absolute Prefrontal White Volume
Psychopathy Total	−.39[a]	−.36[a]	.24	.18
Hare's F1: affective/interpersonal	−.37[a]	−.37[a]	.27	.19
Hare's F2: antisocial lifestyle	−.36[a]	−.33[b]	.16	.12
Cooke's F1: arrogant/deceptive	−.32[b]	−.33[b]	.32[b]	.23
Cooke's F2: affective	−.37[a]	−.36[a]	.19	.14
Cooke's F3: impulsive/unstable	−.29[b]	−.28[b]	.17	.11

F1–F3, Factors 1–3.
[a] $p < .01$, two-tailed test.
[b] $p < .05$, two-tailed test.

factor 2 psychopathy scores (antisocial lifestyle) were entered as a covariate, but group differences remained significant [$F(1,26) = 6.33$, $p = .018$]. Second, we entered a dimensional score of antisocial personality disorder from the SCID as a covariate, but group differences remained significant [$F(1,26) = 4.56$, $p = .043$]. Consequently, group differences in antisocial behavior in general cannot account for the observed results.

Discussion

Results of this study provide initial, provisional answers to the three research questions posed earlier. First, individual differences in psychopathy correlate with volume of prefrontal gray matter, with high total PCL-R scores associated with low prefrontal gray volume. Second, the relationship between psychopathy and prefrontal gray volume is nonspecific in that it was found for all psychopathy factors. Third, unsuccessful psychopaths, but not successful psychopaths, had a 22.3% reduction (16.1 cc) in prefrontal gray matter volumes compared with control subjects. Furthermore, these relationships are specific to prefrontal gray matter and do not generalize to prefrontal white matter or whole brain volume. Results demonstrate for the first time a prefrontal structural deficit in psychopaths. These findings from community psychopaths provide some provisional support for Damasio's (1994, 2000) theory of sociopathic behavior and also provide further support for a differentiation between successful and unsuccessful psychopaths.

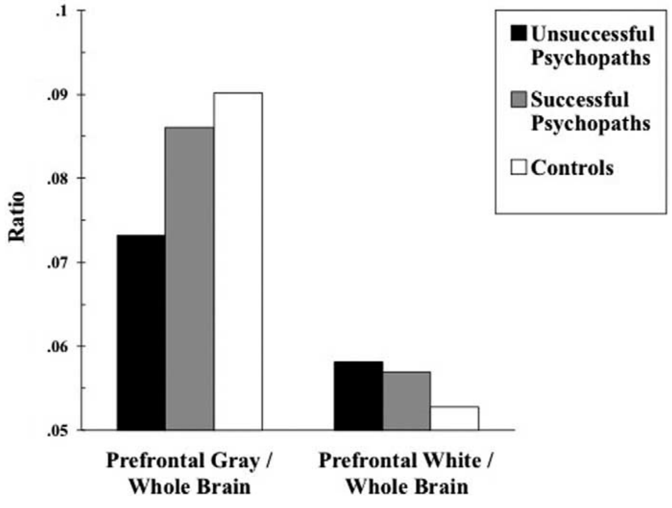

Figure 1. Prefrontal gray and white to whole brain ratios in unsuccessful psychopaths, successful psychopaths, and normal control subjects.

We found significant across-the-board negative correlations between prefrontal gray volumes and total PCL-R scores, Hare's two factors, and Cooke's three factors. The only previous study to assess structural integrity of the prefrontal cortex and subfactors of psychopathy found no significant correlation between total, Hare's factor 1, and Hare's factor 2 psychopathy scores and either prefrontal gray or white matter volumes (Laakso et al 2002). On the other hand, this null effect could be due to a restriction of range as the sample was restricted to violent, alcoholic offenders who also had a diagnosis of antisocial personality disorder. In contrast, psychopathy scores in our community sample ranged from 2 to 40 and were relatively normally distributed. Furthermore, the only imaging study to relate prefrontal functioning to psychopathy factor scores found reduced blood flow to be associated with high factor 1 psychopathy scores (Soderstrom et al 2002). Given the findings from categoric analyses, however, a caveat we must place on these correlational findings is that they are likely carried by the unsuccessful psychopaths who, in contrast to successful psychopaths, show reduced prefrontal volume. Assessing both structural and functional prefrontal characteristics in the same sample in relation to psychopathy in future studies would be desirable to assess whether high psychopathy scores are associated with both structural and functional impairments.

These findings may be best understood in the context of the somatic marker hypothesis of Damasio (1994), which argues that prefrontal structural impairments give rise to poor decision making, autonomic impairments, and sociopathic, dysregulated behavior. These results, in conjunction with previous findings on the same sample, are showing converse but complementary perspective—that is, psychopaths in a community sample have a significant reduction in prefrontal gray matter volume in addition to autonomic and executive function impairments (Ishikawa et al 2001). Neuropsychologic (Morgan and Lilienfeld 2000), psychophysiologic (Kiehl et al 2000), and neurologic studies (Damasio 1994) have for a long time implicated prefrontal impairments in psychopaths, but this research has proven controversial with failures to replicate (Hare 1984). This study provides anatomic evidence to support a prefrontal theory of psychopathy and is consistent with the somatic marker hypothesis of sociopathy (Damasio 1994). Clearly this theoretical perspective is provisional and further structural imaging data on psychopaths are required to verify or refute this position.

Reduced autonomic stress reactivity and executive function deficits have been found in this same group of unsuccessful psychopaths (Ishikawa et al 2001). Poor decision making, reduced autonomic reactivity to cues predictive of punishment, and reduced prefrontal gray may render unsuccessful psychopaths less sensitive to environmental cues signaling danger and capture and hence be more prone to conviction. As outlined earlier, these findings place a caveat on the findings reported earlier on correlations found between high psychopathy scores and reduced prefrontal gray volume in that such a relationship may be specific to unsuccessful (not successful) psychopaths. In contrast to unsuccessful psychopaths, successful psychopaths show a relative sparing of prefrontal gray matter. Relatively intact prefrontal structure may provide successful psychopaths with both the cognitive resources to manipulate and con others successfully, as well as sufficiently good decision-making skills in risky situations to avoid legal detection and capture. In contrast, prefrontal structural deficits may render unsuccessful psychopaths particularly susceptible to poor decision making; interpersonally inappropriate, impulsive, disinhibited, unregulated, reward-driven antisocial behavior; and reduced sensitivity to environmental cues signaling danger and capture—factors placing them more prone to legal detection and conviction.

At least two issues remain unresolved in this study. The first concerns whether prefrontal structural impairments give rise only to poor decision making that then results in capture, or alternatively whether they more broadly predispose to multiple psychopathic traits. Furthermore, given that successful psychopaths do not show prefrontal, hippocampal, autonomic, neurocognitive, and decision-making impairments (Ishikawa et al 2001; Raine et al 2004), what alternative processes give rise to psychopathic features within this group? A second intriguing issue concerns whether the prefrontal structural impairment is localized to the ventromedial region of the prefrontal cortex (Damasio 1994). The unsuccessful psychopaths show a number of similarities observed in patients with ventromedial lesions, including reduced autonomic stress reactivity, poor decision making, prefrontal tissue loss, and normal IQ levels (Ishikawa et al 2001; Raine et al 2004). We were not able to segment the prefrontal cortex to test this possibility. Future imaging studies could both test this hypothesis and further explore other brain impairments that may help explain psychopathic features in successful psychopaths.

We do not believe that prefrontal structural impairments, in and of themselves, cause psychopathic behavior. Instead, it is more likely that more complex disruption to neural circuitry involving the prefrontal cortex predisposes to psychopathic behavioral traits. One such candidate circuit is the septo-hippocampal-frontal system (Gorenstein and Newman 1980). This same sample of unsuccessful psychopaths has an exaggerated structural asymmetry in the anterior hippocampus relative to both successful psychopaths and normal control subjects (Raine et al 2004). These results provide further support for the notion that these two psychopathy groups are distinct subgroups with different autonomic, cognitive, and neuroanatomic deficits. The anterior hippocampal abnormality may be associated with unsuccessful psychopathy by signaling disruption to frontal-subcortical neural circuitry. Animal research has also found that lesions to the septo-hippocampal-frontal system result in behavioral disinhibition and a hypersensitivity to immediate reward (Gorenstein & Newman 1980). Disruption to circuits involving the prefrontal cortex and hippocampus have been implicated in both disrupted emotion regulation and antisocial/aggressive behavior (Davidson 2000; Davidson et al 2000; Hoptman et al 2002; Raine 2002), whereas frontal and executive function deficits are frequently identified in institutionalized psychopathic and antisocial individuals (Moffitt 1993; Raine et al 1998). Conjoint prefrontal and hippocampal structural abnormalities may be critical in shaping psychopathic behavior. Nevertheless, this is only one of a number of possible circuits that needs to be examined in further imaging research on successful and unsuccessful psychopaths.

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