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The Neural Correlates of Moral Decision-Making in Psychopathy

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Neuroimaging studies have used classic moral dilemmas to identify the neural circuitry underlying moral decision-making in healthy individuals, but it is unknown how this circuit functions in immoral, psychopathic individuals. In this functional magnetic resonance imaging (fMRI) study, we find that more psychopathic individuals showed reduced activity in the amygdala during emotional moral decision-making, with particularly conning and manipulative individuals showing reduced activity in the *entire* moral neural circuit. These results provide initial evidence that psychopaths exhibit deficits in brain regions essential to moral judgment in normal individuals.

Psychopathy is a personality disorder involving severe disruption in moral behavior accompanied by pronounced deficits in emotion. Emotion is argued to be a critical component of moral behavior[1]. Highly emotional moral dilemmas have been found to evoke activity in the amygdala, medial prefrontal cortex, posterior cingulate, and angular gyrus[1,2]. It has been hypothesized that persistent immoral behavior may result from deficiencies in some components of the moral neural circuit[3]. We implemented a twice-replicated fMRI task involving classic moral dilemmas[1,2] to examine the relationship between psychopathy and brain activity. We also examined whether four different factors of psychopathy (Fig. 1, middle) were differentially related to neural activation during moral decision-making.

Seventeen community participants with varying degrees of psychopathy (range: 7.4 – 32 on the 40-point Psychopathy Checklist-Revised[4]) made judgments about ten dilemmas of the following types during fMRI scanning in a 3T Siemens Trio scanner (TE = 30 ms, TR = 2 s, flip angle = 80°, FOV = 192 mm): (1) moral personal – emotion-provoking and involving salient harm to another individual (e.g. Should you smother

your crying baby to save yourself and other townspeople hiding from terrorists who may be alerted by the sound?), (2) moral impersonal – less emotional (e.g. Should you keep the money you found in a lost wallet?), and (3) non-moral (e.g. Should you take the train or the bus?).[1,2] We used a second-level multiple regression model on individual activation maps (moral-personal > moral-impersonal) with psychopathy scores (total, factor) as a covariate of interest in SPM5 (http://www.fil.ion.ucl.ac.uk/spm/software/spm5/), masking the analysis to regions-of-interest (5-mm-radius spheres) at previously reported coordinates[2,4] with a statistical threshold corrected for multiple comparisons ($p<0.05$, family-wise error).

Participants with higher psychopathy scores showed reduced activity specifically in the amygdala during emotional moral decision-making (Fig. 1, left). Furthermore, reduced amygdala activity was associated with each of the four factors of psychopathy. In addition to reduced activity in the amygdala, individuals scoring particularly high on the Interpersonal Factor, involving manipulation, conning, superficiality, and deceitfulness, exhibited reduced activity in each of the other regions (medial prefrontal cortex, posterior cingulate, angular gyrus) of the moral neural circuit (Fig. 1, right).

Findings demonstrate that amygdala functioning is disrupted during moral decision-making in psychopathy, and is evident in all features of psychopathy, suggesting that amygdala dysfunction may be a core deficit in psychopathy[5]. The amygdala is thought to respond to cues indicating distress in others, thus guiding individuals away from antisocial behavior[5]. Reduced amygdala functioning in more psychopathic individuals suggests reduced responsivity to the thought of causing harm to others when contemplating personal moral dilemmas. Without such amygdala activation, individuals

may be undeterred from conning and manipulating others, predisposing to impulsive, irresponsible decisions and engaging in criminal behavior without feeling guilt or remorse.

Reduced functioning in medial prefrontal cortex, posterior cingulate, and angular gyrus in individuals high on the Interpersonal Factor of psychopathy may indicate dysfunction of complex social processes important for interpersonal interactions central to behaving morally. These regions have been found to be involved in self-referential thinking, emotional perspective taking, recalling emotional experiences to guide behavior, and integrating emotion into social cognition[3]. Dysfunction in these regions suggests failure to consider how one's actions affect others, failure to consider the emotional perspective of the harmed other, or a failure to integrate emotion into decision-making processes. Such processes are important in determining the appropriateness of *using* someone to achieve a goal, which is central to personal moral dilemmas. Interestingly, particularly conning and manipulative individuals who callously *use* others to achieve goals show reduced functioning in these regions. Overall, findings suggest that reduced functioning in brain regions involved in the complex social process of moral decision-making may partly explain a complex social problem—the psychopath.

References

1 Greene, JD, Sommerville, RB, Nystrom, LE, Darley, JM, Cohen, J. *Science* 2001; **293:** 2105-2108.

2 Greene, JD, Nystrom, LE, Engell, AD, Darley, JM, Cohen, J. *Neuron* 2004; **44:** 389-400.

3 Raine, A, Yang, Y. *Soc Cogn Affect Neurosci* 2006; **1**: 203-213.

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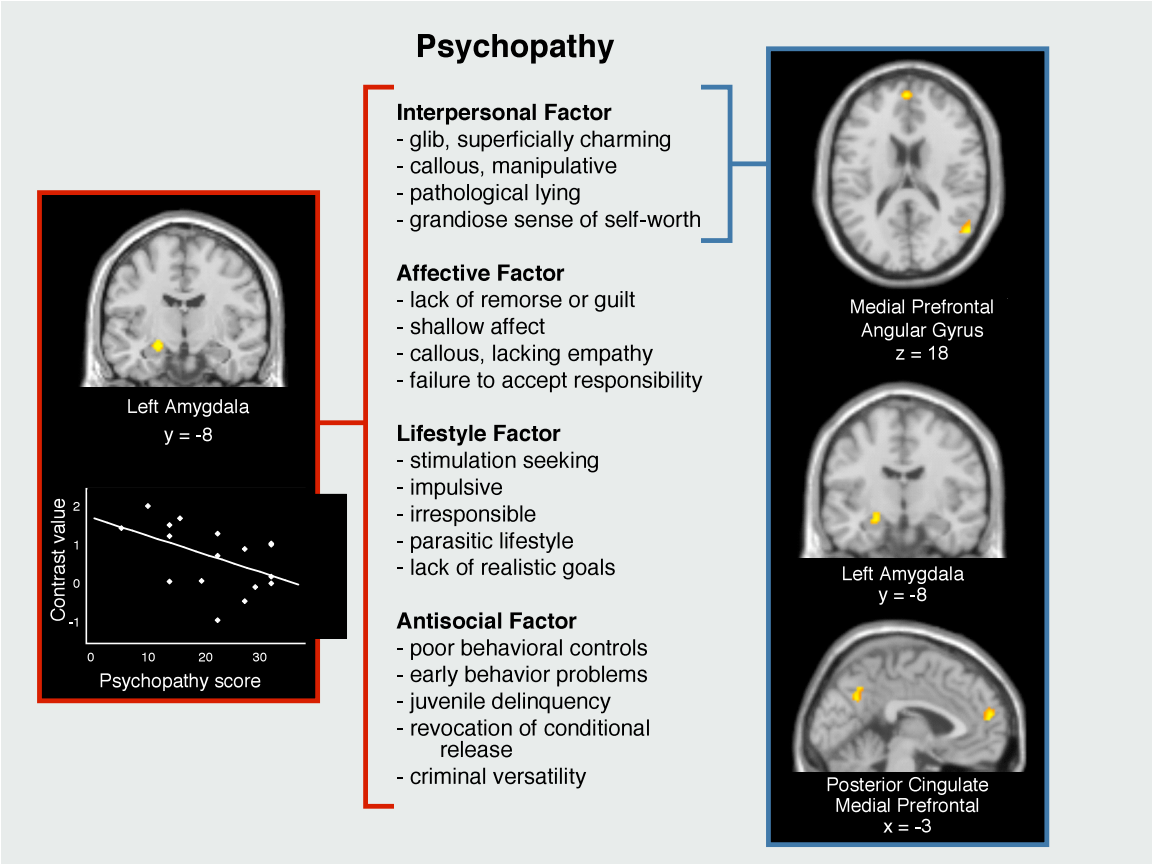
5 Blair, RJ. *Trends Cogn Sci* 2007; **11:** 387-392.

FIGURE 1


Psychopathy
Interpersonal Factor
- glib, superficially charming
- callous, manipulative
- pathological lying
- grandiose sense of self-worth
Affective Factor
- lack of remorse or guilt
- shallow affect
- callous, lacking empathy
- failure to accept responsibility
Lifestyle Factor
- stimulation seeking
- impulsive
- irresponsible
- parasitic lifestyle
- lack of realistic goals
Antisocial Factor
- poor behavioral controls
- early behavior problems
- juvenile delinquency
- revocation of conditional release
- criminal versatility
Left Amygdala
y = -8
Contrast value
2
1
0
-1
0
10
20
30
Psychopathy score
Medial Prefrontal
Angular Gyrus
z = 18
Left Amygdala
y = -8
Posterior Cingulate
Medial Prefrontal
x = -3

Titles and Legends to Figures

Figure 1 Negative association between psychopathy and brain activity during emotional moral decision-making. (**Left**) Higher total psychopathy scores (and all factors of psychopathy) were associated with reduced left amygdala activity (-21, -10, -14; 98 voxels, T = 3.32, p = .011, corrected). (**Middle**) Factors of psychopathy. (**Right**) The interpersonal factor was also associated with reduced activity in medial prefrontal cortex (-4, 60, 14; 98 voxels, T = 2.67, p = .030, corrected), posterior cingulate (0, -66, 35; 14 voxels, T = 2.01, p = .037, corrected), angular gyrus (56, -66, 24; 56 voxels, T = 2.50, p = .012, corrected). No positive associations were significant. Anatomical labels: AMG, amygdala; PCC, posterior cingulate; MPFC, medial prefrontal cortex; ANG, angular gyrus.

SUPPLEMENTARY MATERIAL

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Supplementary Materials and Methods

The following dilemmas used in the present study were selected from a larger set by Greene *et al.*[S1] Full text of the dilemmas is available at http://www.sciencemag.org/cgi/content/full/sci;293/5537/2105/DC1.

Moral-Personal:

Euthanasia

Transplant

Footbridge

Smother for dollars

Crying Baby

Hired Rapist

Infanticide

Preventing the Spread

Modified Bomb

Sacrifice

Moral-Impersonal:

Vaccine Policy

Standard Fumes

Sculpture

Speedboat

Resume

Taxes

Stock Tip

Illegal Lunch

Lost Wallet

Non-moral:

Standard Turnips

Food Prep

Brownies

Computer

Survey

Scenic Route

Broken VCR

Classes

Jogging

Shower

The dilemmas were presented randomly in a series of three blocks of ten dilemmas each. Following Greene *et al.*[S1,S2], each dilemma was presented as text through a series of three screens, the first two describing the scenario and the last posing a question about the appropriateness of an action. Participants read at their own pace, pressing a button to advance screens. After the third screen, participants responded by indicating ("appropriate" or "inappropriate"). The intertrial interval lasted for 14 seconds after each dilemma. Task-related activity was measured using a "floating window" of four images before and one image during the point of response. This epoch was convolved with the hemodynamic response function.

Image preprocessing involved slice timing correction, image realignment and unwarping, normalization into a standard stereotactic space using the Montreal Neurologic Institute (MNI) template, and spatial smoothing with an 8 mm full width at half-maximum Gaussian kernel.

Coordinates for the regions-of-interest (ROIs) are as follows: medial PFC: 1, 52, 17, posterior cingulate: -4, -57.4, 35, angular gyrus, left amygdala: -26, -8, -15, right amygdala: 25, -4, -13. Coordinates were converted from Talairach to MNI coordinates. The cluster threshold was 10 contiguous voxels.

Supplementary Results

Statistics for the negative association between each psychopathy factor and left amygdala activity is as follows: Interpersonal: -21, -14, -14; 63 voxels, T = 3.63, p = .006, corrected; Affective: -21, -14, -21; 70 voxels, T = 2.12, p = .025, corrected; Lifestyle: -18,

-14, -14; 77 voxels, T = 3.51, p = .007, corrected; Antisocial: -18, -14, -14; 70 voxels, T = 3.04, p = .016, corrected.

Supplementary References

S1. Greene, JD, Sommerville, RB, Nystrom, LE, Darley, JM, Cohen, J. *Science* 2001; **293:** 2105-2108.

S2. Greene, JD, Nystrom, LE, Engell, AD, Darley, JM, Cohen, J. *Neuron* 2004; **44:** 389-400.