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Reduced amygdala–orbitofrontal connectivity during moral judgments in youths with disruptive behavior disorders and psychopathic traits

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ABSTRACT

We used functional magnetic resonance imaging (fMRI) to investigate dysfunction in the amygdala and orbitofrontal cortex in adolescents with disruptive behavior disorders and psychopathic traits during a moral judgment task. Fourteen adolescents with psychopathic traits and 14 healthy controls were assessed using fMRI while they categorized illegal and legal behaviors in a moral judgment implicit association task. fMRI data were then analyzed using random-effects analysis of variance and functional connectivity. Youths with psychopathic traits showed reduced amygdala activity when making judgments about legal actions and reduced functional connectivity between the amygdala and orbitofrontal cortex during task performance. These results suggest that psychopathic traits are associated with amygdala and orbitofrontal cortex dysfunction. This dysfunction may relate to previous findings of disrupted moral judgment in this population.

1. Introduction

Psychopathic traits include remorselessness, shallow emotions, lack of empathy, manipulativeness, and irresponsibility. These traits predispose individuals to persistent and severe aggressive and antisocial behaviors and in youths may lead to diagnoses of disruptive behavior disorders such as Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD) (Frick and White, 2008). It has been argued that amygdala and orbitofrontal cortex dysfunction in adolescents with psychopathic traits disrupts emotion-based decision-making, including moral decision making (Blair, 2003; Viding, 2004; Kiehl, 2006; Blair, 2007). On the basis of animal work investigating emotion based decision-making, Schoenbaum and colleagues have stressed the role of the amygdala in stimulus-reinforcement learning and of the orbitofrontal cortex in signaling outcome expectancies (Schoenbaum and Roesch, 2005).

Learning the basics of care-based morality–that some actions harm others and should be avoided and that other actions help others and should be performed–relies on intact functioning of the amygdala and orbitofrontal cortex (Blair, 2007). Specifically, the amygdala's role in stimulus–reinforcement learning may be to allow the individual to learn the goodness or badness of representations of actions. Positively and negatively valenced reinforcement expectancy information provided by the amygdala is then represented as a valenced outcome within the orbitofrontal cortex. Other systems then use this information to allow appropriate decision making, including moral judgments (Blair, 2007).

The functional roles of the amygdala and orbitofrontal cortex may be compromised in youths with psychopathic traits (Blair, 2007). Consistent with this, recent functional magnetic resonance imaging (fMRI) studies have demonstrated that youths with conduct problems and psychopathic traits show atypical amygdala and orbitofrontal cortex activity when viewing fearful or sad expressions and during reversal learning (Finger et al., 2008; Marsh et al., 2008; Jones et al., 2009; Passamonti et al., 2010). Comparable results have been seen in adults with psychopathic traits (Kiehl et al., 2001; Gordon et al., 2004; Birbaumer et al., 2005).

Moreover, both youths with psychopathic traits and adults with psychopathic traits show significant impairment in emotion-based decision making as indexed by both the passive avoidance learning paradigm and the Iowa gambling task (Newman and Kosson, 1986; Blair et al., 2001a; Blair et al., 2004). Youths with psychopathic traits and adults with psychopathic traits are also impaired on some moral judgment tasks (Blair, 1995; Blair et al., 2001b). Consistent with this, psychopathic murderers show a violent implicit association test (IAT) effect for violent actions: they show less of an association between violent actions and unpleasantness and between peaceful actions and pleasantness than do psychopathic non-murderers (Gray et al., 2003).

While fMRI data strongly suggest amygdala and orbitofrontal cortex dysfunction in youths and adults with psychopathic traits (Kiehl et al.,

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2001; Gordon et al., 2004; Birbaumer et al., 2005; Finger et al., 2008; Marsh et al., 2008; Jones et al., 2009), very little of this work has specifically examined decision making. Finger et al. (2008) demonstrated dysfunctional reinforcement outcome signaling in orbitofrontal cortex during reversal learning in youths with psychopathic traits. More critically for this study, a recent fMRI study revealed reduced amygdala activation in adults with high psychopathy scores during a moral decision-making paradigm (Glenn et al., 2009).

In the current study, we examined the neural correlates of moral decision making in youths with psychopathic traits. We used a moral IAT in which participants judged the legality of various actions using button responses that were also associated with either positive or negative judgments (cf. Luo et al., 2006). This task elicits an "IAT effect," whereby participants are slower to judge items as legal (or illegal) when they make their judgments using response buttons associated with opposite-valence items (e.g., making a "legal" judgment with the button used for negative-valence words).

Performance on similar tasks appears to rely on two forms of neuro-computational process (Chee et al., 2000; Phelps et al., 2000; Cunningham et al., 2004; Luo et al., 2006; Beer et al., 2008). The first reflects the representation of the automatic attitude, including its valence, and has been associated with activity within the amygdala and orbitofrontal cortex (Phelps et al., 2000; Cunningham et al., 2004; Luo et al., 2006). The second neuro-computational process reflects mediation of the response conflict that occurs during trials in which the valences of items associated with the same button press are incongruent (e.g., legal actions and negative objects). Such response conflict is typically associated with activity in dorsomedial frontal cortex, dorsal anterior cingulate cortex, and lateral frontal cortex (Chee et al., 2000; Luo et al., 2006; Beer et al., 2008).

The current study tested the hypothesis that youths with psychopathic traits would show decreased amygdala and orbitofrontal cortex activity while performing a moral IAT task. We predicted that these youths would also show reduced amygdala–orbitofrontal cortex connectivity during task performance, as all trial types are hypothesized to be associated with integrated amygdala-orbital frontal cortex activity.

2. Methods

2.1. Participants

Twenty-eight right handed youths participated in this study: 14 youths with ODD or CD and psychopathic traits and 14 healthy comparison youths (Table 1). The youths were recruited from the community through newspaper ads, fliers, and referrals from area mental health practitioners. The study design was reviewed by the Institutional Review Board at the NIMH, and informed assent and consent were obtained from the participants and their parents, respectively, after the nature of the procedures had been fully explained to them.

All youths and parents were administered the Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS-PL) (Kaufman et al., 1997) by an experienced clinician trained and supervised by an expert child psychiatrist (D.S. Pine). Clinicians' assessments show good inter-rater reliability (kappa >0.75 for all diagnoses). Exclusion criteria were pervasive developmental disorder, Tourette's syndrome, current or lifetime history of psychosis, depression, bipolar disorder, generalized, social, or separation anxiety disorder, post-traumatic stress disorder, neurologic disorder, history of head trauma, and IQ less than 80. It should be noted that the K-SADS allows for the identification of substance abuse and substance dependence. No children in either group met criteria for substance abuse or dependence. In addition, parents completed the Antisocial Process Screening Device (APSD), which measures psychopathic traits. Youths meeting K-SADS-PL criteria for CD or ODD and who had APSD scores ≥20 or greater returned to complete the Psychopathy Checklist-Youth Version (PCL-YV) assessment. Only youths scoring ≥20 on the PCL-YV were included in the psychopathic traits group. Healthy controls did not meet criteria for any K-SADS-PL diagnosis and scored <20 on the APSD.

Youths with psychopathic traits on medications were included if their qualifying behaviors and traits were present despite medication. Thus, six youths in the psychopathic traits group who were taking psychoactive medication were included in the study. This included four youths taking simple stimulants (methylphenidate, dexmethylphenidate) who withheld medication for 48 h prior to testing, one youth taking an anti-psychotic (aripiprazole), and one youth taking an anti-depressant (bupropion) and an anti-convulsant (oxcarbazepine). The composition of the two groups of youths was not significantly different in terms of age, IQ and gender (Table 1).

2.2. Clinical measures

2.2.1. Antisocial Process Screening Device (ASPD; Frick and Hare, 2001)

A 20 item parent-completed rating of psychopathic traits and conduct and impulsivity problems for the detection of antisocial processes in youths. A three-factor structure has been characterized comprised of the following dimensions: Callous/Unemotional, Narcissism, and Impulsivity (Frick and Hare, 2001). There is no established APSD cutoff score for classification of high psychopathic traits (Edens et al., 2001; Frick and Hare, 2001; Murrie and Cornell, 2002). Consistent

Table 1
Participant characteristics.

Variable	Psychopathic traits ($N=14$)		Healthy controls ($N=14$)		P
Demographics	Mean	S.D.	Mean	S.D.	
Age, y (range)	14.4 (10.9–16.9)	1.9	13.5	1.7	N.s.
IQ (range)	102.6 (85–118)	8.6	106.0 (83–129)	14.5	N.s.
Male sex, no. (%)	8 (57)		11 (79)		N.s.
DSM-IV diagnoses (current), No. (%)					
Conduct disorder	6 (43)		0		–
Oppositional-defiant disorder	8 (57)		0		–
Attention deficit hyperactivity disorder	9 (64)		0		–
Pediatric psychopathic trait rating scale scores (range)					
Antisocial process screening device	29.5 (25–35)	2.9	6.3 (3–14)	3.6	<0.001
Youth psychopathic traits inventory	113.6 (93–154)	21.4	97.4 (71–131)	19.2	<0.05
Psychopathy checklist: youth version	24.0 (20–32)	3.4	–	–	–