Data supplement for White et al. (doi: 10.1176/appi.ajp.2012.12060840)

Supplemental Methods

Study Measures

Antisocial Process Screening Device (APSD; Frick & Hare, 2001). This is a 20-item parent-completed rating of callous-unemotional (CU) traits and conduct and impulsivity problems (Frick & Hare, 2001), designed to detect psychopathic traits in youths. A three-factor structure has been characterized comprising: CU, narcissism, and impulsivity (Frick & Hare, 2001). Participants' parents completed the ASPD during screening prior to entry into the study.

Participants

All youths and parents completed Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS; Kaufman, Birmaher, Brent, Rao, & et al., 1997) assessments conducted by a doctoral-level clinician as part of a comprehensive psychiatric and psychological assessment. The K-SADS has demonstrated good validity and inter-rater reliability (kappa>0.75 for all diagnoses; Kaufman et al., 1997). The K-SADS assesses for substance abuse and substance dependence but, due to exclusion criteria, no children in either group met criteria for these diagnoses. IQ was assessed with the Wechsler Abbrieviated Scale of Intelligence (two-subtest form). Exclusion criteria were pervasive developmental disorder, Tourette's syndrome, lifetime history of psychosis, depression, bipolar disorder, generalized, social or separation anxiety disorder, PTSD, neurologic disorder, history of head trauma, history of substance abuse, and IQ<70. Youths meeting K-SADS criteria for Conduct Disorder or Oppositional Defiant Disorder were included in the disruptive behavior disorders (DBD) group, while comparison subjects did not meet criteria for any K-SADS diagnosis.

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Supplemental Results

Whole-Brain Analysis Results

In addition to the ROI analysis, a whole-brain analysis was conducted. Again, for the decision-phase analysis, activations modulated by EV to approached objects for DBD youth were compared to healthy comparison youth, as were activations to avoided objects. Similarly, in the feedback phase, activations modulated by PE for DBD youth and healthy comparison youth were contrasted for both rewarded and punished trails.

Initial threshholding was set at $p<0.005$ with an extent threshold of 10 voxels, a combination that has been demonstrated to produce a desirable balance between Type I and Type II error rates (Lieberman & Cunningham, 2009). Average percentage of signal change was measured within each significant cluster of 10 voxels or greater. Because of the significant group difference in IQ scores, activity within the functional ROIs identified by these four *t*-tests were then further analyzed by one-way ANCOVAs with IQ score as a covariate. For all the regions reported below, the introduction of the IQ covariate did not remove the significant differences between groups. In addition, these analyses were performed for a second time following the removal of 7 DBD youth the lowest IQs and the 5 healthy comparison youth with the highest IQs, such that the groups were matched on IQ (see potential confounds below).

Choice-Phase Data Modulated by Expectancies of Reinforcement

Regions showing a significant difference between DBD and healthy comparison youth when chosing stimuli included vmPFC and a region of dorsomedial frontal cortex (dmFC). In both regions, DBD youth showed significantly reduced modulation by expected value (EV) relative to healthy comparison youth when responding to a stimulus.

Regions showing a significant difference between DBD and healthy comparison youth when refusing stimuli included left insula, left caudate, left lateral frontal cortex and right inferior parietal cortex. DBD youth showed significantly reduced modulated activation relative to healthy comparison youth in all regions (see Supplemental Table 1).

Feedback Data Modulated by Prediction Error

When receiving rewarding feedback, DBD youth showed significantly reduced activation modulated by PE relative to healthy comparison youth in left caudate. Regions showing a significant difference between DBD and healthy comparison youth when receiving punishing feedback included rostral and dorsal anterior cingulate cortex (rACC and dACC), left lateral frontal and right superior parietal cortex. Within all regions, DBD youth showed significantly greater modulation of activation by PE relative to healthy comparison youth (see Supplementary Table 1).

Supplementary Table 1: Brain Regions Demonstrating Differential BOLD Responses During Task Performance in 20 Youths with DBD and 18 Healthy Youths

Region [a]	Left/Right	BA	Coordinates of Peak Activation [b] x	y	z	*t*(df=37)	Voxels
DBD Youth vs. Healthy Comparison Youth: Chosen Objects Modulated by Expected Value							
ventromedial prefrontal cortex	Right	11	4.5	58.5	-15.5	3.846	14
dorsomedial frontal cortex	Right	32	7.5	4.5	35.5	4.487	25
culmen	Left	19	-10.5	-58.5	-6.5	3.570	10
DBD Youth vs. Healthy Comparison Youth: Refused Objects Modulated by Expected Value							
anterior insula cortex	Left	13	-31.5	4.5	-9.5	4.457	21
left caudate	Left		-13.5	-1.5	26.5	4.019	27
lateral frontal cortex	Left	9	-52.5	13.5	26.5	3.919	13
inferior parietal lobule	Right	40	49.5	-34.5	47.5	4.896	29
caudate/parahippocampal gyrus	Left		-31.5	-46.5	8.5	3.714	32
uvula	Left		-10.5	-67.5	-33.5	3.401	12
DBD Youth vs. Healthy Comparison Youth: Reward Modulated by Prediction Error							
caudate	Left		-13.5	7.5	11.5	3.647	18
DBD Youth vs. Healthy Comparison Youth: Punishment Modulated by Prediction Error							
caudate	Left		-13.5	22.5	11.5	4.090	10
rostral anterior cingulate cortex	Left	25	-7.5	22.5	-9.5	3.959	11
dorsal anterior cingulate cortex	Left	24	-4.5	1.5	35.5	3.907	18
lateral frontal cortex	Left	9	-43.5	10.5	26.5	3.858	17
superior parietal	Right	7	37.5	-58.8	53.5	3.598	11
middle frontal gyrus	Right	8	25.5	16.5	44.5	4.588	17
superior temporal cortex	Right	38	37.5	-1.5	-15.5	3.898	10
middle temporal cortex	Right	21	55.5	-28.5	-0.5	4.371	23
inferior temporal cortex/fusiform gyrus	Right	37	40.5	-40.5	-18.5	4.137	45
cerebellar tonsil	Left		-34.5	-58.5	-30.5	4.133	19
paracentral lobule	Left	6	-4.5	-31.5	65.5	3.809	15
culmen	Right		13.5	-34.5	-18.5	4.409	25
culmen	Left		-37.5	-46.5	-24.5	3.997	13
culmen	Left		-10.5	-34.5	-12.5	3.935	10

[a] According to the Talairach Daemon Atlas (http://www.nitrc.org/projects/tal-daemon/). [b] Based on the standard brain template of the Montreal Neurological Institute (MNI). BA= Brodmann's Area, df= degrees of freedom

Supplementary Table 2: Brain Regions Demonstrating Differential BOLD Responses During Task Performance in 18 Unmedicated Youths with DBD and 18 Healthy Youths

Region [a]	Left/Right	BA	Coordinates of Peak Activation [b] x	y	z	*t* (df=37)	Voxels
DBD Youth vs. Healthy Comparison Youth: Chosen Objects Modulated by Expected Value							
ventromedial prefrontal cortex	Right	11	4.5	58.5	-15.5	3.674	10
DBD Youth vs. Healthy Comparison Youth: Refused Objects Modulated by Expected Value							
anterior insula cortex	Left	13	-31.5	4.5	-9.5	4.183	19
caudate	Left		-13.5	-1.5	26.5	3.891	26
DBD Youth vs. Healthy Comparison Youth: Reward Modulated by Prediction Error							
caudate	Left		-13.5	7.5	11.5	3.556	5
DBD Youth vs. Healthy Comparison Youth: Punishment Modulated by Prediction Error							
caudate	Left		-13.5	22.5	11.5	4.090	10

[a] According to the Talairach Daemon Atlas (http://www.nitrc.org/projects/tal-daemon/). [b] Based on the standard brain template of the Montreal Neurological Institute (MNI). BA= Brodmann's Area, df= degrees of freedom
DBD= disruptive behavior disorders

Supplementary Table 3: Brain Regions Demonstrating Differential BOLD Responses During Task Performance in 16 Youths with DBD, but Without ADHD and 18 Healthy Youths

Region [a]	Left/Right	BA	Coordinates of Peak Activation [b] x	y	z	*t* (df=37)	Voxels
DBD Youth vs. Healthy Comparison Youth: Chosen Objects Modulated by Expected Value							
ventromedial prefrontal cortex	Right	10	4.5	58.5	-15.5	3.690	10
DBD Youth vs. Healthy Comparison Youth: Refused Objects Modulated by Expected Value							
anterior insula cortex	Left	13	-31.5	4.5	-9.5	3.963	13
left caudate	Left		-13.5	-1.5	26.5	3.662	21
DBD Youth vs. Healthy Comparison Youth: Reward Modulated by Prediction Error							
caudate	Left		-13.5	7.5	11.5	3.556	5
DBD Youth vs. Healthy Comparison Youth: Punishment Modulated by Prediction Error							
caudate	Left		-13.5	22.5	11.5	4.587	9

[a] According to the Talairach Daemon Atlas (http://www.nitrc.org/projects/tal-daemon/). [b] Based on the standard brain template of the Montreal Neurological Institute (MNI). BA= Brodmann's Area, df= degrees of freedom
DBD= disruptive behavior disorders, ADHD= Attention Deficit-Hyperactivity Disorder

Supplementary Table 4: Characteristics of DBD Youth and Healthy Youth Matched for IQ

	DBD Youth (N=13)		Healthy Youth (N=13)	
Characteristic	Mean	(SD)	Mean	(SD)
Age (years)	15.32	(2.12)	15.09	(2.17)
IQ[a]	97.77	(5.95)	103.69	(10.61)
APSD	25.69**	(7.97)	6.46**	(4.26)
CU	7.68**	(2.69)	1.31**	(1.65)
NAR	9.37**	(3.05)	1.15**	(1.46)
IMP	7.28**	(2.02)	1.54**	(0.97)
	N	%	N	%
Gender	10 male	(76.92% male)	8 male	(61.54% male)
Race/ethnicity	12 minority	(95.00%)	9 minority	(55.56%)
		DSM-IV Diagnoses		
CD	11	84.6%	0	0%
ODD	2	15.4%	0	0%
ADHD	4	30.8%	0	0%

SD = Standard Deviation
DBD= disruptive behavior disorder
APSD= Antisocial Process Screening Device, CU= APSD Callous-Unemotional subscale, NAR= APSD Narcissism subscale, IMP= APSD Impulsive/Antisocial subscale
CD= Conduct Disorder, ODD= Oppositional Defiant Disorder, ADHD= Attention Deficit Hyperactivity Disorder
[a] Assessed with the Wechsler Abbreviated Scale of Intelligence (two-subtest form)
** significantly different at $p < .001$

Supplementary Table 5: One sample *t*-tests Comparing BOLD Response During Decision-Making and Feedback to Baseline Activation in DBD Youth and Healthy Youth

	DBD Youth		Healthy Youth	
Region	*t* (df=17)	*p*	*t* (19)	*p*
Chosen Objects Modulated by Expected Value				
vmPFC	-3.357	.002	2.155	.046
Refused Objects Modulated by Expected Value				
AIC	-2.820	.011	2.994	.008
Rewarding Feedback Modulated by Prediction Error				
caudate	-1.760	.095	4.121	.001
Punishing Feedback Modulated by Prediction Error				
caudate	3.779	.001	-2.191	.043

df = degrees of freedom, DBD= disruptive behavior disorder
vmPFC= ventromedial prefrontal cortex, AIC= anterior insula cortex

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