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Processing of Differentially Valued Rewards and Punishments in Youths with Bipolar Disorder or Severe Mood Dysregulation

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Abstract

Background—Youths with chronic irritability and hyperarousal (i.e., severe mood dysregulation, SMD) have reward- and punishment-processing deficits distinct from those exhibited by children with episodic symptoms of mania (i.e., narrow-phenotype bipolar disorder, BD). Additionally, youths with SMD, like those with psychopathy, have prominent reactive aggression. Therefore, we hypothesized that SMD, but not BD, youths would be impaired on a decision-making task that has identified reward- and punishment-processing deficits in individuals with psychopathy.

Methods—A decision-making task was used in which BD ($n = 23$), SMD ($n = 37$), and control subjects ($n = 31$) were asked to choose between two images associated with different levels of reward or punishment.

Results—No between-group differences in task performance were found.

Conclusion—These results suggest that BD, SMD, and normal youths do not differ in their ability to select between rewards and punishments of different value. Effect-size analyses suggest that this finding is not secondary to a type II error. Unlike individuals with psychopathy, neither SMD subjects nor those with BD differ from controls in their ability to select between differentially valued rewards and punishments.

INTRODUCTION

IN CHILDREN AND ADOLESCENTS, bipolar disorder (BD) is one of the most debilitating psychiatric illnesses, often resulting in academic and social difficulties, hospitalization, and/or suicidality (Wilens et al. 2003; Dickstein et al. 2005). However, questions remain regarding the diagnosis of pediatric BD, because it has been suggested that mania in youths may present with chronic irritability rather than an episodic mood disturbance (Carlson et al. 1998; Leibenluft et al. 2003). To facilitate research on these questions, Leibenluft et al. proposed a system of pediatric bipolar phenotypes that includes: (1) a “narrow-phenotype” BD characterized by euphoria and an episodic course and (2) a “broad phenotype” of severe mood dysregulation (SMD) defined by irritability and a nonepisodic course (Leibenluft et al. 2003). It is important to ascertain whether this phenotypic categorization maps onto pathophysiological differences between these groups. Such mapping may also carry implications for pharmacological intervention, as such interventions may one day be targeted toward the underlying pathophysiology in these specific syndromes.

Because depression is characterized by anhedonia, whereas mania is associated with hyperhedonia, researchers have studied reward processing in youths with BD. Data indicate that both BD and SMD phenotypes exhibit impairment in their ability to adapt to changing reward contingencies (Dickstein et al. 2004; Gorrindo et al. 2005; Dickstein et al. 2007). However, the specific pattern of this cognitive flexibility impairment differs between the two groups (Dickstein et al. 2007). Moreover, from a clinical perspective, SMD subjects resemble not only those with BD, but also individuals with psychopathy. That is, subjects with SMD or psychopathy both exhibit a reduced threshold for responding aggressively when frustrated or threatened (i.e., reactive aggression), although only psychopathic individuals show an abnormal tendency to use aggression instrumentally to achieve a specific desired goal (i.e., proactive aggression) (Blair et al. 2006).

A study using the Differential Reward/Punishment Learning Task (DRPLT) developed by Blair and colleagues showed that individuals with psychopathy are impaired in their ability to select between different levels of reward and punishment. Impairment was most marked with respect to the ability to select between two punishments of different value (Blair et al. 2006). Given the above-noted clinical similarities between psychopathy and SMD, further characterization of SMD impairment using the DRPLT is warranted. Although some subjects with BD may also exhibit reactive aggression, this clinical feature is not as prominent as in SMD or psychopathy. Therefore, we hypothesized that the DRPLT may differentiate the SMD and BD phenotypes pathophysiologically. The DRPLT assesses selection of rewarding and punishing stimuli based on their relative value and involves three different trial conditions. In these conditions, subjects must choose between: (1) two differentially rewarding stimuli, or (2) two differentially punishing stimuli, or (3) one rewarding and one punishing stimulus (Blair et al. 2006).

Given the clinical and pathophysiological distinctions between BD and SMD, and the clinical similarities between SMD and psychopathy, we hypothesize that BD subjects will perform similarly to controls on the DRPLT, whereas SMD subjects will exhibit deficits similar to those of individuals with psychopathy—that is, poorer performance across all trial types, especially pronounced for the punishment/ punishment condition.

METHOD

Subjects

Subjects included 23 BD, 37 SMD, and 31 control children and adolescents. Parents and children gave written informed consent/assent. BD inclusion criteria involved fulfillment of *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition, Text Revision (DSM-IV-TR) (American Psychiatric Association 2000) criteria for bipolar disorder. In addition, children and adolescents with irritability only during their manic/hypomanic episodes, without elevated or expansive mood, were excluded from the BD group (Leibenluft et al. 2003).

SMD inclusion criteria included: (1) abnormal mood (anger or sadness), present at least half of the day most days; (2) hyperarousal (at least three of the following: insomnia, agitation, distractibility, racing thoughts or flight of ideas, pressured speech, intrusiveness); (3) markedly increased reactivity to negative emotional stimuli, manifested verbally and/or behaviorally at least three times a week; (4) symptoms cause severe impairment in at least one setting (home, school, or peers) and at least mild impairment in a second setting. Symptom onset occurred before age 12 and symptoms were not episodic (i.e., they had been present for at least 12 months without symptom free periods greater than 2 months) (Leibenluft et al. 2003).

Exclusion criteria for both groups, as well as control subjects, included: intelligence quotient (IQ) < 70, age less than 7 or greater than 18 years, pervasive developmental disorder, substance

abuse, pregnancy, or medical illness that was unstable or could cause mood symptoms. Additionally, SMD exclusion criteria included distinct manic or hypomanic episodes lasting a day or more.

Clinicians administered the Child Schedule for Affective Disorders Present and Lifetime Version (K-SADS-PL) (Kaufman et al. 1997), with an additional SMD supplement, to determine whether subjects met BD or SMD criteria. These diagnostic measures were administered by trained graduate-level clinicians with established interrater reliability ($\kappa = 0.9$). The Young Mania Rating Scale (YMRS) (Young et al. 1978) and Children's Depression Rating Scale (CDRS) (Poznanski et al. 1984) were administered within 1 week of task completion. The Wechsler Abbreviated Scale of Intelligence (WASI) was used to assess IQ (Wechsler 1999).

Psychopathic tendencies were evaluated using the Antisocial Process Screening Device (APSD) (Frick and Hare 2001). Items in the APSD were also subdivided for analysis of three factors: (1) narcissism, (2) impulsivity, and (3) callous-unemotional trait (Frick et al. 1994). Proactive and reactive aggression were evaluated using an adaptation of the Reactive and Proactive Aggression questionnaire, with items rated on a 5-point, rather than 3-point scale (Dodge and Coie 1987; Coie et al. 1991). The APSD and the Reactive and Proactive Aggression questionnaire were completed by parents either at the time of task performance or at a later date by telephone.

Behavioral task

Subjects completed the DRPLT devised by Blair et al. (Blair et al. 2006). The DRPLT consists of 10 images that each depict a different object from the Snodgrass Vanderwart picture set (Snodgrass and Vanderwart 1980). Each image has a randomly assigned value (−900, −700, −500, −300, −100, 100, 300, 500, 700, or 900). During the task, images are presented in pairs. The subject is told that one of the two images must be chosen on each trial, and that some images will result in losing points and that some will result in winning points. There is no time limit for making a selection. Following image selection, the assigned value is revealed on the screen, and subjects are told how many points they have won or lost on any given trial.

There are three task conditions: Reward/Reward, Punishment/Punishment, and Reward/Punishment (see Fig. 1). In the Reward/Reward condition, both images are associated with rewards (point values 100, 300, 500, 700, or 900). In the Punishment/Punishment condition, both images are associated with punishments (point values −100, −300, −500, −700, or −900). In the Reward/Punishment condition, one image is associated with a reward and one image with a punishment. The subject's goal in each of these conditions is to choose the image that will gain them the most points or lose them the least points.

In addition to these three overall task conditions, the task also involves different inter-stimulus reinforcement distances (that is, the numerical difference between the point values associated with the particular images that are presented; see Fig. 2). The point differences are divided into three different interstimulus reinforcement distances: far (e.g., 100 vs. 900), medium (e.g., 100 vs. 500), and close (e.g., 700 vs. 900). Therefore, the DRPLT involves a 3 (Group: BD vs. SMD vs. control) by 3 (Trial type: Reward/Reward, Reward/Punishment, Punishment/Punishment) by 3 (Distance: Far, Medium, Close) experimental design. The DRPLT was programmed in VisualBasic and presented on a laptop computer.

Data analysis

Each subject performed 234 trials. Only those trials occurring after the subject completed enough trials to view each of the 10 images at least once were included in analyses. For each

trial, the subject's response was scored as "correct" if the more valuable image was chosen over the less valuable image. For example, on punishment/punishment trials where both images represented a loss (e.g., -100 and -300), choosing the image representing the smaller loss (-100) was scored as correct. Because each subject performed more Reward/Punishment trials than either Reward/Reward or Punishment/Punishment trials, the number of errors was converted to an error percentage and arcsine transformed to improve the distribution for statistical comparisons (Kirk 1995).

Data were analyzed with the SPSS (version 15.0). All tests performed were two-tailed analyses with $p < 0.05$. One-way analyses of variance (ANOVAs) were used to ascertain whether the three groups (BD, SMD, and control) differed in continuous demographic variables. Chi-square tests were performed to determine whether groups differed by categorical measures. Because the groups differed in age and IQ (see Results, below), a 3 (Group: BD vs. SMD vs. control) by 3 (Trial type: Reward/Reward, Reward/Punishment, Punishment/Punishment) by 3 (Distance: Far, Medium, Close) repeated-measures analysis of covariance (ANCOVA), with age and IQ as covariates, was used to examine differences in the rate of correct responses. Greenhouse–Geisser corrected values were reported, given a significant Mauchly's test of sphericity. Additionally, outliers were identified and their influence on the results was examined using residuals and Cook's distances. Effect sizes were calculated using Cohen's d (Cohen 1988).

The initial ANCOVA showed an interaction between trial type and IQ (see Results, below), thereby violating the homogeneity of regression assumption for covariates. Therefore, the analysis was repeated using IQ-matched subjects. Because insufficient sample sizes were available to match all three groups at once, separate matching was performed between the control and SMD groups (within 2 IQ points) and between the bipolar and SMD groups (within 5 IQ points). Following matching, there were no significant age differences among the groups. Therefore, age was not used as a covariate, and group by trial type by interstimulus reinforcement distance full-factorial repeated-measures ANOVAs were performed.

Secondary analyses to evaluate the effects of co-morbid attention-deficit hyperactivity disorder (ADHD), oppositional-defiant disorder (ODD), and anxiety disorders were performed by using each of these co-morbidities as a covariate in separate analyses of group task performance. In particular, each co-morbidity was used as a covariate in a separate 3 (Group: BD vs. SMD vs. control) by 3 (Trial type: Reward/Reward, Reward/Punishment, Punishment/Punishment) by 3 (Distance: Far, Medium, Close) repeated-measures ANCOVA, also covaried for age and IQ.

Pearson correlations were used to assess associations between task performance and mood ratings (YMRS and CDRS scores), psychopathy ratings, and aggression ratings.

RESULTS

DRPLT task results

The DRPLT was performed by 23 BD, 37 SMD, and 31 control subjects (see Table 1). Between-group differences in IQ were significant ($F_{(2,88)} = 7.24, p = 0.001$) with SMD subjects exhibiting significantly lower IQs than the other two groups. Between-group differences in age were also significant ($F_{(2,88)} = 3.64, p = 0.03$). Therefore, IQ and age were used as covariates in a repeated-measures ANCOVA. Residuals and Cook's distances were examined to identify outliers and determine their influence on the results. Eliminating cases with high values on these measures did not alter the results. Therefore, the analyses reported below include the original data.

There was a significant main effect of trial type ($F_{(2,170)} = 12.26, p < 0.001$). Subjects exhibited a significantly higher error rate for punishment/punishment trials compared to reward/punishment ($p < 0.001$) and reward/reward trials ($p = 0.004$). In addition, more errors were made in the reward/reward trials compared to reward/punishment trials ($p < 0.001$) (see Fig. 3 and Table 2).

A significant main effect of distance was also observed ($F_{(2,169)} = 4.89, p = 0.009$). Subjects' error rates increased as the interstimulus reinforcement distance decreased (see Fig. 4 and Table 3). As expected, across all subjects and all trial types, error rates increased as the difference between stimulus point values decreased.

Contrary to the study hypothesis, there was no significant main effect of group (BD vs. SMD vs. control) on overall task performance ($F_{(2,86)} = 0.03, p = 0.97$). Furthermore, there were no significant interactions of group by trial type ($F_{(4,170)} = 1.66, p = 0.16$) or group by interstimulus reinforcement distance ($F_{(4,169)} = 1.53, p = 0.20$). Effect sizes (Cohen's d) were small ($d < 0.08$) for the between group comparisons (see Table 4; Cohen 1988).

There was a significant interaction between trial type and IQ ($F_{(2,170)} = 6.44, p = 0.002$). As described above (see Methods), the analysis was therefore repeated in subsamples of subjects matched for IQ. Subjects did not differ in age. Both analyses yielded no main effect of group (control vs. SMD: $F_{(1,19)} = 0.15, p = 0.70$; BD vs. SMD: $F_{(1,16)} = 0.35, p = 0.57$). There was no group by trial type interaction (control vs. SMD: $F_{(2,37)} = 1.06, p = 0.36$; BD vs. SMD: $F_{(2,27)} = 0.40, p = 0.68$) or group by distance interaction (control vs. SMD: $F_{(2,37)} = 2.08, p = 0.14$; BD vs. SMD: $F_{(2,32)} = 1.51, p = 0.24$). As in the primary analysis, effect sizes for the between group comparisons were small (control vs. SMD: $d = 0.18$; BD vs. SMD: $d = 0.29$).

Regarding assessment of power and effect sizes for this data set as a whole, a formal post hoc power analysis using the overall observed group sizes in the present study indicates that Cohen's d effect sizes in the range of 0.69–0.79 would be required to achieve a power of 0.80. Given that the effect sizes for the primary group comparisons in this study are small and near zero (and remain of similar size despite controlling for potentially confounding factors; see Table 4), the likelihood of showing group differences, even in a larger sample, is minimal.

Post hoc analyses: Mood state

For BD subjects, there were no significant correlations between either YMRS or CDRS scores and performance on any trial type ($r > -0.19$ and < 0.11). For SMD subjects, there was a significant positive correlation between YMRS scores and error rates on reward/punishment trials ($r = 0.42, p = 0.01$), and a significant negative correlation between CDRS scores and error rates on reward/reward trials ($r = -0.34, p = 0.04$). However, once these results were corrected for multiple comparisons, the results were no longer significant.

A comparison of euthymic BD (YMRS ≤ 12 and CDRS < 40 ; $n = 11$), euthymic SMD (CDRS < 40 ; $n = 33$), and control subjects' performance yielded results that were comparable to those found in the original analysis using all subjects. No significant group by trial-type or group by interstimulus reinforcement distance interactions was identified.

Post hoc analyses: Psychopathy and aggression

A comparison of task performance between SMD and BD youths with and without psychopathy could not be performed due to the very limited number of BD ($n = 2$) and SMD subjects ($n = 6$) meeting APSD criteria for psychopathy (i.e., APSD ≥ 25) (Blair et al. 2001). Of note, 5/23 BD, 7/37 SMD, and 10/31 control subjects' APSD scores could not be obtained.

Pearson correlations between ASPD subscale scores and task performance were assessed for each trial type. For the BD group, correlations between reward/reward trial performance and narcissism ($r = -0.54, p = 0.02$) and between punishment/punishment trial performance and proactive aggression ($r = -0.48, p = 0.04$) were significant. For the SMD group, the correlation between reward/reward performance and impulsivity was significant ($r = 0.40, p = 0.03$). Finally, for healthy controls, punishment/punishment performance was significantly correlated with impulsivity ($r = -0.50, p = 0.03$) and callousness ($r = -0.45, p < 0.05$). Of note, while these analyses should be considered exploratory, none of the correlations remained significant after correction for multiple comparisons.

Post hoc analyses: Co-morbidities

Post hoc ANCOVAs were conducted to assess associations between task performance and comorbid ADHD, ODD, and anxiety disorders. Adjusting for these co-morbidities separately did not alter the original DRPLT results. None of these factors was a significant contributor to the models predicting task performance (ADHD, $p = 0.09$; ODD, $p = 0.44$; anxiety, $p = 0.61$).

Post hoc analyses: Psychotropic medications

Analyses were conducted to evaluate the effect of psychotropic medications on task performance. Unmedicated SMD subjects ($n = 11$) were compared to medicated SMD subjects ($n = 26$) and control subjects. Results were generally similar to the original analysis. No main effect of group, group by trial type interaction, or group by interstimulus reinforcement distance interaction was found. However, a group by trial type by interstimulus reinforcement distance interaction was significant ($F_{(7,205)} = 2.27, p = 0.03$). Post hoc tests showed that controls made more errors on reward/reward trials and punishment/punishment trials compared to reward/punishment trials regardless of the interstimulus reinforcement distance. This finding was consistent with results from the overall repeated-measures ANCOVA using all subjects. However, there were complex and differing interactions between trial type and interstimulus reinforcement distance in the medicated and unmedicated SMD subjects, none of which supported a consistent, predicted pattern of performance deficits. Given the small sample size ($n = 11$) in the unmedicated SMD group, the number of statistical tests performed, and the fact that these interactions were not consistent with any theory-driven a priori hypotheses, we did not conduct further post hoc analyses. Analyses comparing medicated and unmedicated patients with BD could not be performed due to an insufficient number of unmedicated BD subjects ($n = 3$).

DISCUSSION

The current study sought to differentiate the pathophysiology of BD and SMD by using the DRPLT. Research demonstrating such distinct pathophysiologic profiles may one day support attempts to develop psychopharmacological agents targeted to these specific syndromes. On the basis of shared clinical features, we hypothesized that SMD subjects might perform similarly to individuals with psychopathy on the DRPLT. Specifically, we hypothesized that the SMD youths would show impairment across all task conditions (punishment/punishment, reward/reward, and reward/punishment conditions), and that this impairment would be particularly pronounced for the punishment/punishment condition. However, SMD youths did not differ from controls in performance on the DRPLT. Similarly, BD subjects and controls did not differ on task performance. Of note, the previous studies indicating reward-processing deficits in youths with BD or SMD used tasks that involve changing reward contingencies (Dickstein et al. 2004; Gorrindo et al. 2005; Dickstein et al. 2007), which does not occur in the DRPLT task.

The fact that patients with psychopathy, but not those with BD or SMD, differ from controls on the DLPRT highlights some of the clinical features differentiating psychopathy from these two other clinical syndromes. Although both psychopathy and SMD are characterized by reactive aggression, individuals with psychopathy are distinguished from other psychopathological groups, including SMD, by the presence of more prominent proactive aggression (Williamson et al. 1987; Cornell et al. 1996; Blair et al. 2006). Additionally, psychopathy in children and adolescents is closely associated with features of conduct disorder (Christian et al. 1997). Significantly, no SMD youths in our sample met criteria for a concurrent diagnosis of conduct disorder (CD).

The SMD syndrome, unlike psychopathy, also involves a significant mood and anxiety component. For example, nearly half of the SMD subjects in this sample exhibited comorbid anxiety disorders (15/37 subjects, see Table 5). In contrast, there is a significant negative correlation between anxiety and the emotional dysfunction specific to psychopathy— that is, features such as shallow affect, callousness, and lack of remorse or guilt (Harpur et al. 1989; Patrick et al. 1994; Frick et al. 1999; Verona et al. 2001). Moreover, low scores on social anxiety scales may predict later risk for development of conduct disorder (Pine et al. 2000). Of note, such longitudinal findings should be distinguished from findings emerging in other studies, focusing on cross-sectional associations. These cross-sectional studies generally find increased rates of anxiety and depression in patients with CD (Angold et al. 1999). The fact that SMD and psychopathic individuals differ in anxiety symptomatology is particularly significant, given that recent data indicate that individuals with anxiety disorders perform differently from individuals with psychopathy on the DRPLT. Specifically, relative to controls, subjects with generalized anxiety disorder show generalized impairment across all DRPLT conditions (DeVido et al. in preparation).

The longitudinal courses of SMD and psychopathy may differ as well, with SMD youths at particular risk for depression in early adulthood (Brotman et al. 2006). In contrast, psychopathic traits are negatively correlated with depression (Lovelace and Gannon 1999; Soderstrom et al. 2005). Finally, whereas both SMD and youths with psychopathy have deficits processing facial emotion, the exact nature of the deficit differs. That is, youths with psychopathic tendencies have specific deficits processing fearful and sad facial expressions, whereas youths with SMD have nonspecific processing deficits across a range of facial emotions (Blair et al. 2001; Rich et al. 2008).

This study has several limitations. Because the sample sizes are small, there is the risk of a type II error. However, the effect size of the observed differences between groups was small (see Table 4; Cohen 1988), making this an unlikely explanation for our negative results. Additionally, a number of subjects were taking psychotropic medications, which could impact task performance.

Interpretation of SMD and BD DRPLT results may also be limited by a lack of comparative DRPLT data for youths with psychopathy. All prior studies of the DRPLT have involved adult subjects and adult psychopathology, and therefore developmental differences might also account for our lack of findings in youth subjects. Comparative DRPLT data for youths with psychopathic traits would be particularly valuable in allowing a direct comparison between SMD, psychopathic, and control performance, and might provide for a more definitive distinction between SMD and youths with psychopathy.

In sum, individuals with SMD and those with psychopathy share some clinical similarities in their propensity for reactive aggression. However, the two groups also differ symptomatically, in that SMD youths have prominent mood and anxiety symptoms, while only individuals with psychopathy have extensive proactive aggression. Moreover, individuals with SMD and those

with psychopathy exhibit different deficits on facial emotion recognition. Finally, unlike individuals with psychopathy, SMD subjects do not differ from controls in their performance on the DRPLT. More research is needed to investigate the extent to which clinical features shared between SMD and psychopathy represent any common pathophysiological processes underlying these two disorders.

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FIG. 1.

The Differential Reward/Punishment Learning Task: Trial types. **The three different trial types are:** (1) Reward/ Reward: Subjects choose between two rewarding images, each representing a different point value gain; (2) Punishment/ Punishment: Subjects choose between two punishing images, each representing a different point value loss; and (3) Reward/ Punishment: Subjects choose between a rewarding image, representing point gain, and a punishing image, representing point loss.

FIG. 2.

The Differential Reward/Punishment Learning Task: Interstimulus reinforcement distances.

The three different interstimulus reinforcement distances are: (1) Far: Subjects choose between images associated with a greater difference in point values (e.g., +100 vs. +900 points); (2) Medium: Subjects choose between images associated with an intermediate difference in point values (e.g., +100 vs. +500 points); and (3) Close: Subjects choose between images associated with a lesser difference in point values (e.g., +100 vs. +300 points).

FIG. 3.

Mean error rates by trial type. Mean error rates following arcsine transformation, covaried for IQ and age, for Punishment/Punishment, Reward/Reward, and Reward/Punishment trial types. Error bars represent standard error. No significant between-group differences in task performance were found. BD = bipolar disorder subjects; SMD = severe mood dysregulated subjects. IQ = Intelligence quotient.

FIG. 4.

Mean error rates by interstimulus reinforcement distance. Mean error rates following arcsine transformation, covaried for IQ and age, for Close, Medium, and Far interstimulus reinforcement distances. Error bars represent standard error. No significant between-group differences in task performance were found. IQ = Intelligence quotient; BD = bipolar disorder subjects; SMD = severe mood dysregulated subjects.

TABLE 1
Group Characteristics And Ratings For Psychopathy, Aggression, And Mood Scales

	BD (n = 23)		SMD (n = 37)		Controls (n = 31)		Overall between-group difference (p)	BD/SMD between-group difference (p)	BD/control between-group difference (p)	SMD/control between-group difference (p)
	Mean/n	SD	Mean/n	SD	Mean/n	SD				
Gender (male)	n = 15		n = 23		n = 17					
Age (in years)	14.2	2.60	12.5	2.35	13.5	2.59	0.71	NA	NA	NA
IQ	112	15.1	101	11.7	114	16.8	0.03	0.03	1.00	0.24
Medicated	n = 20		n = 26		n = 0		0.001	0.02	1.00	0.002
YMRS	11.9	6.06	13.4	5.86	NA		NA	0.81	NA	NA
CDRS	29.5	8.26	28.8	8.98	NA		NA	0.33	NA	NA
APSD score	14.7	4.78	19.8	4.37	6.09	4.40	NA	0.78	NA	NA
Factor 1: Narcissism	5.29	3.24	7.61	2.56	1.95	1.39	<0.001	<0.001	<0.001	<0.001
Factor 2: Impulsivity	5.82	2.04	7.00	1.54	2.65	1.76	<0.001	0.01	<0.001	<0.001
Factor 3: Callous/Unemotional	3.82	1.91	5.42	2.04	1.70	2.13	<0.001	0.10	<0.001	<0.001
Rective aggression	3.78	2.34	4.57	1.55	1.10	1.14	<0.001	0.04	0.007	<0.001
Proactive aggression	2.22	2.39	1.90	1.47	0.095	0.30	<0.001	0.37	<0.001	<0.001
Total aggression	6.00	4.58	6.47	2.45	1.19	1.29	<0.001	1.00	<0.001	<0.001

Abbreviations: BD = bipolar disorder subjects; SMD = severe mood dysregulated subjects; YMRS = Young Mania Rating Scale (Young et al. 1978); CDRS = Children's Depression Rating Scale (Poznanski et al. 1984); APSD = Antisocial Process Screening Device (Frick and Hare 2001; Frick et al. 1994); SD = standard deviation; NA = not applicable.

TABLE 2
Mean Error Rates By Trial Type (Following Arcsine Transformation; Covaried For Iq And Age)

Group	Punishment/ punishment		Reward/reward		Reward/ punishment		All conditions	
	Mean error	SD	Mean error	SD	Mean error	SD	Mean error	SD
BD	0.208	0.158	0.151	0.153	0.089	0.0959	0.149	0.120
SMD	0.185	0.164	0.184	0.158	0.099	0.103	0.156	0.122
Control	0.232	0.156	0.157	0.156	0.083	0.100	0.158	0.117
All	0.185	0.124	0.151	0.124	0.126	0.133	0.154	0.114

Abbreviations: BD = bipolar disorder subjects; SMD = severe mood dysregulated subjects; SD = standard deviation.

TABLE 3
Mean Error Rates By Interstimulus Reinforcement Distance (Following Arcsine Transformation; Covaried For Iq And Age)

Group	Close		Medium		Far		All	
	Mean error	SD	Mean error	SD	Mean error	SD	Mean error	SD
BD	0.190	0.120	0.144	0.125	0.114	0.129	0.149	0.120
SMD	0.181	0.128	0.164	0.134	0.123	0.134	0.156	0.122
Control	0.185	0.122	0.146	0.128	0.142	0.134	0.158	0.117
All	0.185	0.124	0.151	0.124	0.126	0.134	0.154	0.114

Abbreviations: BD = bipolar disorder subjects; SMD = severe mood dysregulated subjects; SD = standard deviation.

TABLE 4Between-Group Significance For Task Performance, Interactions, And Effect Sizes^a

<i>Type of analysis</i>	<i>Group (p)</i>	<i>Group by trial type (p)</i>	<i>Group by interstimulus reinforcement distance (p)</i>	<i>Effect size: group (d)</i>
IQ-matched SMD (<i>n</i> = 20) vs control (<i>n</i> = 20) ANOVA	0.70	0.36	0.14	0.18
IQ-matched SMD (<i>n</i> = 17) vs. BD (<i>n</i> = 17) ANOVA	0.57	0.68	0.24	0.29
Age/IQ-covared SMD (<i>n</i> = 37) vs BD (<i>n</i> = 23) vs. control (<i>n</i> = 31) ANCOVA	0.97	0.16	0.20	<0.08

^aBetween-group significance for task performance, group by trial type interactions, group by interstimulus reinforcement distance interactions, and Cohen's *d* effect sizes (Cohen 1988) using subjects' arcsine transformed error rates. BD = bipolar disorder subjects; SMD = severe mood dysregulated subjects; ANOVA = analysis of variance; ANCOVA = analysis of covariance; IQ = intelligence quotient.

TABLE 5**Subjects With Co-Morbid Psychiatric Conditions**

<i>Co-morbidity</i>	<i>BD n (%)</i>	<i>SMD n (%)</i>
Major depressive disorder	13 (57%)	4 (11%)
Obsessive-compulsive disorder	2 (9%)	0 (0%)
Posttraumatic stress disorder	2 (9%)	0 (0%)
Attention-deficit/hyperactivity disorder	9 (39%)	30 (81%)
Oppositional defiant disorder	6 (26%)	32 (86%)
Conduct disorder	1 (4%)	0 (0%)
Panic disorder	1 (4%)	0 (0%)
Separation anxiety disorder	3 (13%)	7 (19%)
Social anxiety disorder	4 (17%)	3 (8%)
Generalized anxiety disorder	5 (22%)	11 (30%)
Any anxiety disorder	8 (35%)	15 (41%)

Abbreviations: BD = bipolar disorder subjects; SMD = severe mood dysregulated subjects.