Behavioral Alterations in Reward System Function: The Role of Childhood Maltreatment and Psychopathology

AMANDA E. GUYER, PH.D., JOAN KAUFMAN, PH.D., HILARY B. HODGDON, B.S., CARRIE L. MASTEN, M.A., SANDRA JAZBEC, M.S., DANIEL S. PINE, M.D., AND MONIQUE ERNST, M.D.

ABSTRACT

Objective: To examine in children the influence of maltreatment and associated psychiatric sequelae on behavioral responses to reward stimuli. **Method:** A computerized two-choice decision-making task involving probabilistic monetary gains was used to probe elemental processes of goal-directed actions. Using different risk contingencies, the authors examined decision-making, expectations of outcomes, and affective responses to rewards in 38 maltreated children and 21 demographically matched controls (8–14 years old). **Results:** Maltreated children selected risk options faster than controls; however, whereas controls responded more quickly as the chance of winning increased, maltreated children did not vary in response speed as a function of the likelihood of winning. When choosing between high- and low-risk options, maltreated children with depressive disorders more frequently selected safe over risky choices than did controls. No group differences emerged in self-report ratings of positive or negative reactions to winning or not winning, respectively. **Conclusions:** This initial experimental study of responses to reward lays the groundwork for subsequent research on neurodevelopmental aspects of reward processes in relationship to maltreatment and psychopathology. Clinical applications of these data may be relevant for developing treatment plans for maltreated children, particularly those with depression. *J. Am. Acad. Child Adolesc. Psychiatry*, 2006;45(9);1059–1067.
Key Words: posttraumatic stress disorder, decision-making, risk-taking, motivation, depression.

Childhood maltreatment has been associated with psychiatric illnesses (Famularo et al., 1992), including major depressive disorder (MDD) (Kaufman, 1991), substance abuse disorders (Dube et al., 2003; Kendler et al., 2000), and posttraumatic stress disorder (PTSD; Pelcovitz et al., 1994; Rasmusson and Charney, 1997). Perturbations in motivation for and in response to pleasurable or rewarding stimuli characterize each of these disorders. It is unknown, however, whether maltreated children also exhibit alterations in reward behavior as a result of their histories of significant stress (Heim et al., 2004).

Reward-related disturbances occur in mood, substance abuse, and posttraumatic disorders. Cardinal features of MDD include lack of interest and anhedonia in daily life, reduced motivation for seeking pleasure, and decreased pleasure from rewarding stimuli (Hasler et al., 2004). Substance abuse disorders present with an uncontrollable, overriding drive to use drugs and alcohol, despite knowledge of associated negative consequences (Koob

Accepted February 21, 2006.

Drs. Guyer, Pine, and Ernst are with the Mood and Anxiety Program, National Institute of Mental Health, Bethesda, MD; Dr. Kaufman is with the Department of Psychiatry, Yale University, New Haven, CT; Ms. Hodgdon is with the Department of Psychology, Temple University, Philadelphia; Ms. Masten is with the Department of Psychology, University of California, Los Angeles; and Ms. Jazbec is with the Department of Psychology, University of Zurich, Zurich, Switzerland.

The authors thank the children, families, and the Connecticut Department of Children and Families staff who facilitated this work. This research was supported in part by the NIMH/NIH Intramural Research Program, NIMH grant 1R01MH65519-01 (J.K.), monies from the state of Connecticut (J.K.), and support from the National Center for PTSD (J.K.).

Correspondence to Dr. Amanda E. Guyer, Mood and Anxiety Program, Emotional Development and Affective Neuroscience Branch, National Institute of Mental Health, National Institutes of Health, 15K North Drive, Room 208, MSC 2670, Bethesda, MD 20892-2670; e-mail: amandaguyer@mail.nih.gov.

0890-8567/06/4509–1059©2006 by the American Academy of Child and Adolescent Psychiatry.

DOI: 10.1097/01.chi.0000227882.50404.11

and Le Moal, 2001; Nestler et al., 2002). PTSD symptoms include persistent re-experiencing of traumatic events, deliberate avoidance of event-related stimuli, and numbing of general responsiveness, all of which involve increased arousal, reduced approach behavior, and emotional blunting (Yehuda, 2004). PTSD is also highly comorbid with both MDD and substance abuse (Breslau et al., 1997; Kessler et al., 1995). Across these disorders, reward-related perturbations may influence decision-making and motivation for risk-taking, expectations of outcomes, and affective responses to rewards and punishments.

Recent preclinical research has linked early life stress with alterations in motivated behavior. The early life stress paradigms used in preclinical research are intended to simulate maltreatment in humans. For example, early maternal separation produced enduring effects on adult rats' behavioral responsivity to appetitive stimuli (Matthews and Robbins, 2003). Similarly, monkeys repeatedly deprived of caregiving exhibited more anhedonic behaviors and less interest in rewards relative to control monkeys (Pryce et al., 2004). A study in rats showed that anhedonia, but not chronic stress per se, was associated with analogues of depressive symptoms (e.g., decreased exploration of novelty; Strekalova et al., 2004). Stress alone was related to hyperactive locomotion, an analogue of increased anxiety. These stress-related alterations of motivated behavior resemble human affective symptoms associated with mood, posttraumatic stress, and substance abuse disorders.

It is unknown whether similar reward perturbations affect children who have been maltreated. Together, preclinical and clinical findings emphasize the need for investigations examining associations between maltreatment, reward-system function, and psychopathology (Heim et al., 2004; Naranjo et al., 2001). To address this gap in the literature, we used a recently developed experimental paradigm that manipulates risk contingencies (Ernst et al., 2004a). This paradigm is based on prospect theory, which purports that humans tend to be risk-seeking when given the choice to avoid potential losses and to be risk-averse when faced with potential gains (Kahneman and Tversky, 1979). Although no human studies have examined explicitly associations between maltreatment and reward/punishment sensitivity, we proposed specific hypotheses based on the most common symptoms following exposure to extreme stress. We hypothesized that because of the stress it imposes, maltreatment is associated with reduced sensitivity to positive stimuli (reward) manifest as emotional numbing and anhedonia and enhanced sensitivity to negative stimuli (punishment) resulting in avoidance. Consistent with these hypotheses, we predicted that relative to controls, maltreated children would exhibit (1) preference of safe over risky choices based on numbing of general response to stimuli, which may reduce attractiveness of novel stimuli; (2) reduced ability to discriminate among different reward values based on presumed reduced sensitivity to reward; and (3) bias toward negative affective responses based on presumed enhanced sensitivity to punishment. In addition, the contribution of psychiatric illnesses (i.e., depressive disorders [DDs], PTSD, and externalizing [EXT] disorders) to these reward-system dysfunctions was explored.

METHOD

Participants

Participants were 38 maltreated children and 21 nonmaltreated demographically matched controls. Maltreated children were removed from their homes by the State of Connecticut Department of Children and Families (DCF) because of abuse and/or neglect and placed temporarily in state-run facilities for assessment and treatment planning. Controls had no involvement with protective services and no history of maltreatment or domestic violence exposure. Controls were recruited from the same communities as the maltreated children. Annual household income for all participants was <$30,000. Children were 8 to 14 years old (mean = 11.44 ± 1.67). Groups did not differ as to gender, age, or IQ (measured with the Wechsler Intelligence Scale for Children-Revised [WISC-R]; Sattler, 1992; Wechsler, 1974; Table 1). The proportion of younger and older participants did not differ between groups, $\chi^2(1, N = 59) = 0.03$, $p = .86$.

Procedures

The Yale University Human Investigations Committee and Connecticut DCF Institutional Review Board approved this study. Caseworkers introduced the study to maltreated children's birth mothers and obtained permission for research staff to contact birth mothers. Of DCF families who were approached, 95% agreed to participate. Controls were recruited through advertisements and targeted mailings.

Study information was fully described to children's legal guardians, who then provided signed consent for participation. Interviewers read aloud study information to the children. Children assented by initialing or signing their name on an assent form. All of the parents and children agreed to participate. In the event that a birth parent could not be located, DCF caseworkers consented as the child's custodian.

Children underwent baseline interviews at their current place of residence. Maltreated children's parents and control families were interviewed at home; some maltreating parents were interviewed in prison or DCF offices. Children received $15 and parents received

TABLE 1
Sample Characteristics

	Maltreated (*n* = 38)	Controls (*n* = 21)	χ^2	*t* Test	*p* Value
Gender	21 males	12 males	.02		ns
Age[a]	11.53 (1.54)	11.28 (1.91)		−0.51	ns
IQ[a]	94.37 (12.14)	90.95 (12.03)		−1.04	ns
MFQ[a]	17.61 (11.41)	9.55 (7.22)		−3.28	.002
SCARED[a]	28.38 (16.74)	23.30 (10.03)		−1.43	ns
PTSD[b]	25 (64.8)	0			0[c]
DD[b]	14 (35.9)	1 (5.8)			.01[c]
EXT[b]	12 (31.6)	2 (9.5)			ns[c]

Note: Current/past and probable/definite diagnoses included. Diagnosis frequencies do not add up to total sample because of comorbid disorders. ns = not significant; MFQ = Mood and Feelings Questionnaire; SCARED = Screen for Child Anxiety Related Emotional Disorders; PTSD = posttraumatic stress disorder; DD = major depressive disorder, dysthymic disorder, and/or depressive disorder not otherwise specified; EXT = attention-deficit/hyperactivity disorder, oppositional defiant disorder, and/or conduct disorder.

[a] Mean (SD).

[b] Number (%).

[c] Probabilities from two-tailed Fisher exact test for cells with fewer than five participants.

$25 for participating. Approximately 1 month after baseline interviews, children attended a 1-week summer day camp during which the decision-making task was administered. Fewer controls than maltreated children attended camp, resulting in unequal groups.

Measures

Psychopathology. A semistructured psychiatric interview was administered to each child and at least one of the child's biological parents using the Schedule for Affective Disorders and Schizophrenia for School Aged Children-Present and Lifetime Version (K-SADS-PL; Kaufman et al., 1997). When both birth parents were unavailable for the interview, the Child Behavior Checklist (Achenbach and Rescorla, 2001) was completed by a foster parent or residential care staff member (for 5% of the maltreated children). Children's teachers completed the Teacher Report Form (Achenbach and Rescorla, 2001). Children reported on depressive (Mood and Feelings Questionnaire; Wood et al., 1995), anxiety (Screen for Child Anxiety Related Emotional Disorders; Birmaher et al., 1997), and PTSD (Child PTSD Checklist; Amaya-Jackson et al. [1995, 2000]) symptoms. Best-estimate diagnostic procedures generated *DSM-IV*-based diagnoses (Leckman et al., 1982). Clinical materials (i.e., self-reports, teacher reports, psychiatric interview) were reviewed at a multidisciplinary team meeting led by an expert in assessing maltreatment and psychopathology (J.K.). Final diagnoses were assigned by consensus agreement.

Three variables were created to indicate presence/absence of a probable (presence of impairment and ≥85% of required symptoms) or definite diagnosis of (1) PTSD, (2) DDs, including MDD, dysthymic disorder, or depressive disorder not otherwise specified, and (3) EXT disorders, including attention-deficit/hyperactivity disorder, oppositional defiant disorder, and/or conduct disorder. Current and past diagnoses were included.

Maltreated children had higher depressive symptoms than controls; both groups showed similar levels of anxiety symptoms (Table 1). Significantly more maltreated children met criteria for PTSD and DDs than controls. Three of 21 controls had at least one current or past psychiatric diagnosis; none had PTSD.

Maltreatment. Data on maltreatment were extracted from DCF computerized records and caseworker reports. Parents completed the K-SADS-PL PTSD section, which surveys a range of traumas, and the Partner Violence Inventory, a 37-item measure of domestic violence (e.g., emotional/physical abuse, sexual exploitation; Bernstein, 1998). Children's self-reports of traumatic experiences were obtained using the Childhood Trauma Questionnaire (Bernstein and Fink, 1998).

Data from multiple informants and sources (e.g., caseworkers, parents, children, DCF case records) were synthesized for the best possible quantitative estimate of maltreatment history using the coding systems in Kaufman et al. (1994) and Schweder (2003). Severity of physical abuse, sexual abuse, neglect, emotional abuse, and domestic violence exposure was rated 0 (not evident) to 4 (extreme forms) by two raters trained in these methods by the study's principal investigator. Intraclass correlation (ICC) reliability estimates for maltreatment subtypes were computed from 10 training cases (physical abuse ICC = 0.87; sexual abuse ICC = 0.97; neglect ICC = 0.84; emotional abuse ICC = 0.96; domestic violence ICC = 0.93).

Reward-Related Processing. The Wheel of Fortune (WOF) is a computerized two-choice decision-making behavioral task with reward and punishment contingencies (Ernst et al., 2004a). The WOF presents a decision-making challenge by having participants choose between a low probability of a large reward and a high probability of a small reward. The WOF paradigm uses the counterfactual effect in which the affective value of gains is relative to potential outcomes that were not selected (Kahneman and Tversky, 1979). Drawing on this principle, decision-making patterns as well as neuroimaging findings support that the "zero" in gain versus zero-gain experiments is a negative outcome and "zero" in loss versus zero-loss experiments is a rewarding outcome (Breiter et al., 2001; Ernst and Paulus, 2005; Mellers et al., 1997). The WOF task assesses decision-making processes in a positive context (win/no-win) and negative context (lose/no-lose) separately. Because of time constraints, the lose/no-lose task was not used. Previous behavioral (Ernst et al., 2004a) and neuroimaging (Ernst et al., 2004b, 2005) findings suggest the win/no-win task may be more effective than the lose/no-lose task at eliciting stronger responses.

Research assistants trained participants on the WOF. To enhance motivational salience of the task, children were instructed to win as much money as possible to receive gift certificates reflecting their final dollar amounts (mean = $43; range = $24.50–$55).

The WOF has four wheels shown in random order. Each wheel has two options (i.e., a pink or blue slice) divided into proportions of 10/90, 30/70, or 50/50. Each option is paired with a dollar amount. Smaller proportions accompany higher dollar amounts (10/90 condition: $4/$0.5; 30/70 condition: $1/$0.5; 50/50 condition: $0.5/$0.5 or $4/$4), reflecting the likelihood and magnitude of gains for each option. Spatial representation of these probabilities allows participants to gain an intuitive sense about each option's value. Each trial has three phases: risk selection, anticipation, and affective response to outcomes (Fig. 1).

Risk Selection. Children were to choose the option they thought an imaginary pointer would land on if the wheel were actually spun by pressing 1 for the left side of the pie (pink) or 2 for the right side of the pie (blue). If the computer selected the same option, then the participant won the associated money; if the computer selected the other option, then the participant won nothing. The task was programmed to generate outcomes according to the probability for selected options. Four conditions were created to elicit behaviors entailing various degrees of risk-taking: (1) 10% chance of winning $4.00; 90% chance of winning $0.50; (2) 30% chance of winning $1.00; 70% chance of winning $0.50; (3) 50% chance of winning $0.50; and (4) 50% chance of winning $4.00. The task consisted of two runs yielding 62 trials in total (10/90 condition = 22; 30/70 condition = 16; 50/50 conditions = 24), allowing for full randomization and distribution of outcomes. The task was self-paced whereby the screen advanced when participants responded.

Reward Anticipation. After selecting an option, participants rated their confidence in winning using a 5-point scale (1 = not sure; 5 = very sure).

Affective Response. Participants were then presented with the outcome. For favorable outcomes (i.e., won money), children rated how they felt on a 5-point scale (1 = same as before; 5 = really happy). Children made similar ratings for unfavorable outcomes (i.e., did not win; 1 = same as before; 5 = really sad).

Response time (RT) was recorded in milliseconds (ms) when participants made their selections, anticipation ratings, and subjective feeling ratings by a button-press on the computer.

Data Analysis

Conditions refer to the four wheel types: 10/90, 30/70, 50/50-$0.50, and 50/50-$4. Options refer to the five slices of each wheel: 10, 30, 50 (includes high and low rewards), 70, and 90% chance of winning. Risky options were slices 10 and 30. Safe options were slices 70 and 90.

Decision-making patterns were assessed with mean frequency of selection for each condition, except the 50/50 conditions for which risk level did not vary. Mean frequency was calculated as the number of times the option was selected divided by the number of times a selection was made (e.g., number of 10% options selected/(number of 10% options selected + number of 90% options selected)) and ranged from 0 (always safe options) to 1 (always risky options).

RTs <150 ms or 2.5 SDs above the mean were considered invalid (e.g., impulsive responding, inattention to the cue) and set to

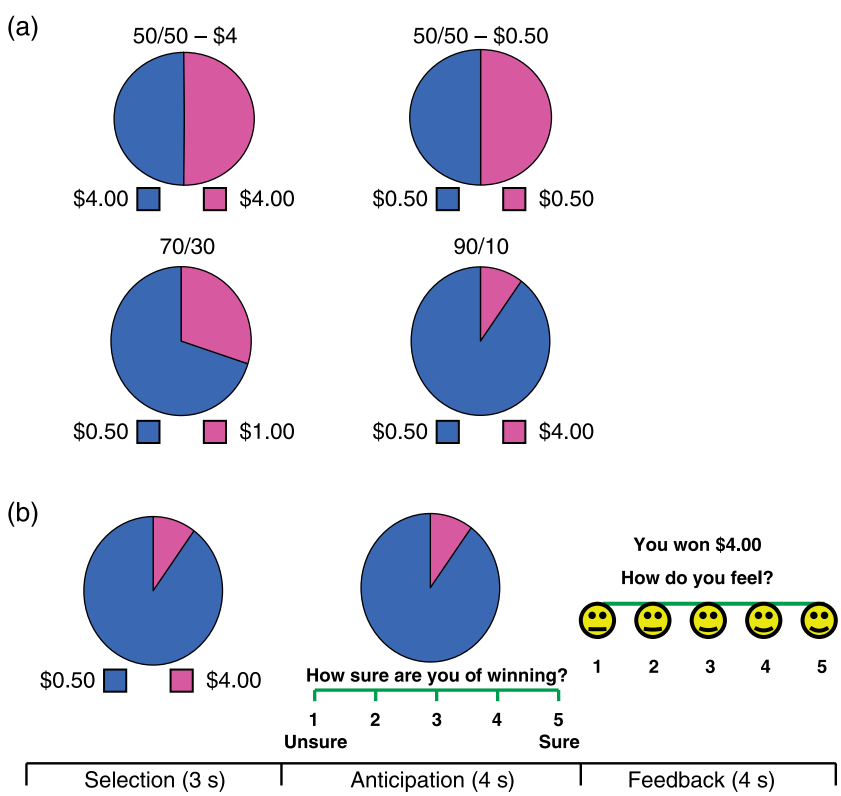

Fig. 1 Four conditions (a) and three phases (b) of the Wheel of Fortune task.

missing. Groups did not differ on number of missing trials within conditions. Mean RT was calculated for risk options across all trials. When a child did not select a particular option (e.g., never selected 10%, always selected 90%), RT was missing on that option. Because of these missing data points, 10 children (five controls, five maltreated) were not retained in analyses using all five options.

Repeated-measures analyses of variance compared maltreated children and controls on each measure. Similar analyses were conducted to examine the effect of psychiatric diagnosis on task performance. Greenhouse-Geisser correction for nonsphericity was used when necessary and is denoted by epsilon (ε). Effect size is reported for all analyses using partial eta-squared (η^2). Significant effects were followed with least significant difference (LSD) multiple comparison tests. A two-tailed significance level ($\alpha < .05$) was used for all statistical tests. No significant correlations emerged among age, gender, or IQ and reward measures in the whole sample or by group. Because of potential influences of developmental level on task performance, younger (8–11.5 years) and older (11.6–14 years) participants were grouped using a median split. Results from analyses of variance indicated no age effects for any of the measures; thus, performance did not differ by age group.

RESULTS

Analyses comparing maltreated children and controls are presented first, followed by maltreatment-psychiatric diagnosis subgroup analyses. After separating outcomes into favorable and unfavorable, power to detect group differences was halved, and no group differences emerged in affective responses. These measures are not discussed further.

Maltreated Versus Control Group Analyses

Risk Selection. A significant main effect of risk condition, $F_{1,57} = 8.49$, $p < .01$; $\eta^2 = 0.13$, indicated that for high risk, children selected riskier options (10% chance of winning \$4) less often than safer options (90% chance of winning \$0.50), whereas for moderate risk, children selected riskier options (30% chance of winning \$1) more often than safer options (70% chance of winning \$0.50). There were no significant effects of group or group × risk condition on selection type.

A significant group × option interaction was found for mean RT to select options, $F_{4,188} = 3.11$, $p < .05$; $\varepsilon = 0.74$; $\eta^2 = 0.06$. Figure 2 displays RTs by group as risk level varied from high to low. Maltreated children made their selections at relatively similar speeds across options, whereas controls took longer to select higher risk than lower risk options. LSD tests indicated no significant differences among maltreated children between any options; for controls, selection of 90% options was significantly faster than 10% (mean difference = 905.51, SE = 309.56, $p < .01$), 30% (mean difference = 539.44, SE = 212.02, $p < .05$), 50% (mean difference = 561.10, SE = 222.83, $p < .05$), and 70% (mean difference = 609.08, SE = 221.15, $p < .01$) options. There was no significant group effect on reaction time (i.e., no overall differences between groups). Similarly, there was no main effect of option on reaction time (i.e., no overall differences between options).

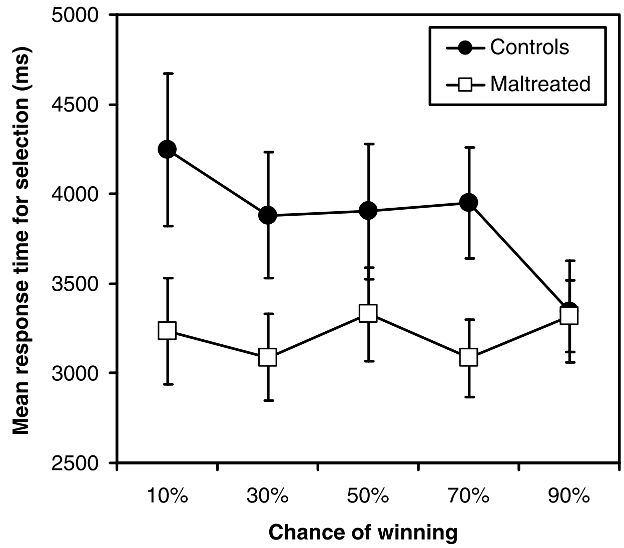

Fig. 2 Interaction of option and group on mean response time of selection. Note that lower response time indicates faster response.

Reward Anticipation. A main effect of option was found for children's anticipation ratings of winning, $F_{4,188} = 6.75$, $p < .001$; $\varepsilon = 0.72$; $\eta^2 = 0.13$, whereby participants anticipated being more likely to win as the chance of winning increased. The group effect and group × option interaction were not significant.

Maltreatment-Psychiatric Diagnosis Subgroup Analyses

Analyses examining psychopathology included subgroups of maltreated children classified by probable/definite psychiatric diagnosis: those with DDs ($n = 14$) and without DDs ($n = 24$), with PTSD ($n = 25$) and without PTSD ($n = 13$), and with EXT disorders ($n = 12$) and without EXT disorders ($n = 26$). Analyses compared each subgroup to controls ($n = 21$). Most maltreated children had more than two diagnoses; thus, maltreatment-diagnosis comparisons are not orthogonal. Of the 25 maltreated children with PTSD, 12 had comorbid DDs, 10 had comorbid EXT disorders, and four had both DDs and EXT disorders comorbid with PTSD. Among controls, one child had probable DD not otherwise specified, two were diagnosed with attention-deficit/hyperactivity disorder, and none had PTSD. Because results appeared

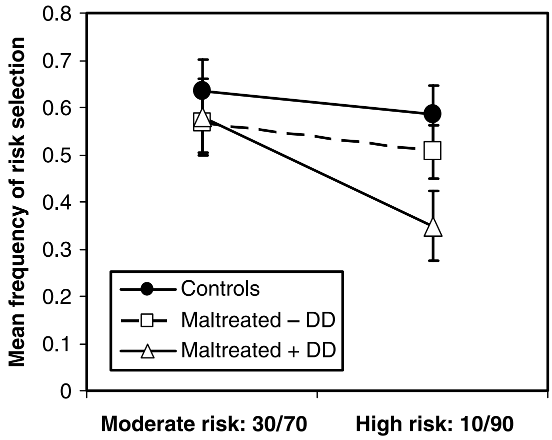

Fig. 3 Interaction of risk condition and group on mean frequency of risk selection (10 of 10/90; 30 of 30/70). 0 = always selects safest option; 1 = always selects riskiest option.

similar without these control subjects, their data were retained in analyses. Age, gender, and IQ were similar between the diagnostic subgroups.

PTSD and EXT disorders subgroups showed no effects on performance scores. Only DD results are presented below.

Risk Selection. Classifying maltreated children by DDs yielded a significant group × risk condition interaction on mean frequency of risk selection, $F_{2,56}$ = 3.75, $p < .05$; $\eta^2 = 0.12$. Maltreated children with DDs selected safe over risky options more frequently in the high-risk condition than did controls (mean difference = 0.24, *SE* = 0.10, $p < .05$; Fig. 3). The groups selected similarly in the moderate-risk condition.

Comparing maltreated children with and without DDs and controls revealed a significant group × option interaction in RT to select options, $F_{4,184}$ = 2.29, $p < .05$; $\varepsilon = 0.75$; $\eta^2 = 0.09$. LSD tests indicated that for maltreated children without DDs, selection time was longer in response to 90% options than to 30% options (mean difference = 385.88, *SE* = 188.11, $p < .05$). For maltreated children with DDs, RT was longer for 50% than 70% options (mean difference = 679.09, *SE* = 333.10, $p < .05$). Main effects of group or option were not significant.

Reward Anticipation. For anticipation ratings, a main effect of option was found for each subgroup: DDs, $F_{4,184}$ = 9.58, $p < .001$; $\varepsilon = 0.72$; $\eta^2 = 0.17$; PTSD, $F_{4,184}$ = 9.75, $p < .001$; $\varepsilon = 0.72$; $\eta^2 = 0.18$; and EXT, $F_{4,184}$ = 10.51, $p < .001$; $\varepsilon = 0.72$; $\eta^2 = 0.19$. Regardless of group, children reported greater anticipation of winning as the chance of winning increased. No significant main or interaction effects were found for any maltreatment subgroups on RT to rate anticipation.

DISCUSSION

The present study is the first investigation of behavioral responses to manipulations of risk and reward in maltreated and demographically similar nonmaltreated children. Two main findings emerged. First, maltreated children and controls differed in sensitivity to selecting reward values associated with different risk levels. Maltreated children's RTs were invariant as the likelihood of winning changed. Controls, however, responded more quickly as the chance of winning increased. Only for the highest probability (i.e., 90%) of winning did both groups respond at comparable speeds. Second, children with histories of significant maltreatment who also met diagnostic criteria for DDs avoided selecting a large reward paired with a low chance of winning compared with maltreated children without DDs and controls.

Although hypothesized group differences in children's confidence in winning were not confirmed, confidence ratings paralleled the actual likelihood of winning set by the task (i.e., greater confidence after selecting larger slices). The WOF successfully manipulated anticipation because participants were attuned to the predictive value of their actions. This is an important control that supports task validity.

Support was found for our hypothesis regarding group differences in sensitivity to discriminating reward values during decision making. Maltreated children's consistently fast pattern of response, regardless of risk condition, may suggest a reduced sensitivity to different reward values. One possible interpretation is that a fast RT reflects elevated arousal, a core symptom of PTSD, or impulsivity. A second possible interpretation is that a history of significant stress from maltreatment rather than psychopathology per se may alter the reward system by enhancing impulsive responses and/or reducing sensitivity to rewards. Our past work found that maltreated children were faster than controls at categorizing emotional facial expressions displaying fear, but categorized happy and neutral faces at similar speeds (Masten et al., 2004). This suggests that RT may be specific to affective context of the task and may be influenced by the neural circuits mediating emotion processing. Additional studies are needed to better understand the nature of this enhanced response speed.

Our hypothesis regarding maltreated children's tendency to favor safe over risky choices was partially supported. This decision-making pattern was present only in maltreated children with DDs. This finding may be interpreted in several ways: abnormally low risk-taking may result from maltreatment and depression combined or be independent of maltreatment and solely related to depressive symptoms. Future studies need to include depressed, nonmaltreated children to address this question. The decision-making pattern that emerged in this sample may reflect decreased reward sensitivity, increased punishment sensitivity (absence of expected reward), or limited resources to manage conflict associated with risky behavior. Indeed, past work has suggested reduced reward sensitivity in depressed patients (Henriques et al., 1994; Tremblay et al., 2005). Associations between reward dysfunction and anhedonia have been identified at the basis of certain depression endophenotypes (Hasler et al., 2004), which may account for the depressed maltreated group's lack of motivation to select options with a greater payoff. The unique behavioral pattern revealed in maltreated children with depression may have preceded depression onset thereby indexing a specific vulnerability, or may be secondary to depression.

Group differences were not detected in affective responses to outcomes. It is possible that maltreatment may not affect these components of reward-processing until later in adolescence, at ages older than our sample. However, differences may not have been detected because of the small sample size for favorable and unfavorable outcomes.

Together, the main findings suggest that conservative decision making was associated with DDs and not maltreatment per se, whereas response sensitivity was related to maltreatment regardless of diagnoses. These findings broadly parallel those of a preclinical study of maternal separation in rats (similar to maltreatment types experienced by children in this study) demonstrating that anhedonia plus chronic stress was associated with avoidance of novelty, whereas chronic stress alone was related to hyperactive behavior (Strekalova et al., 2004). In our study, maltreated children with DDs avoided making high-risk decisions, whereas maltreated children responded more quickly to rewards overall. Despite inherent differences in conceptualizing reward-related behavioral responses in human and animal samples, preclinical studies provide opportunities to replicate and extend findings in human populations (Spear, 2000).

Limitations

The high-risk condition of the WOF involves choosing a large reward paired with a low chance of winning whereby not winning money is a punishment. This outcome may not be as adverse as some risk-taking situations encountered in real-world settings. However, a number of studies based on economic theories have shown that not winning in the context of potential gain is a negative experience (Breiter et al., 2001; Mellers et al., 1997; Paulus et al., 2001).

This study included children spanning a wide age range (8–14 years old). The lack of significant age effects on task performance in this sample does not exclude the possibility that developmental level could differentially influence performance. A larger sample would provide greater power to detect age effects. The groups, however, did not differ in age and age was not related to WOF performance scores.

This study may have been underpowered by a small sample size and the loss of data points as a result of nonrandom reasons (e.g., invalid responses). Furthermore, groups were unequal in size, which may influence analyses; however, our previous work in this sample found group differences whereby maltreated children with PTSD avoided attending to threatening faces (Pine et al., 2005). This suggests that despite unequal groups, maltreated children differ from controls on multiple measures of emotion- and attention-related processes.

These findings may only apply to specific populations of children. The sample is from families of low socioeconomic status; maltreated children were recruited through protective service agencies. This latter method has the advantage of verifying maltreatment, but it may introduce referral biases. To identify maltreatment effects more precisely, a group with depressive symptoms but no maltreatment and PTSD could be a valuable addition to a "pure" healthy group in future work.

Finally, children who experience acute maltreatment over a shorter time frame may respond differently on the WOF than chronically maltreated children. Maltreatment chronicity may also differentially affect the development of psychopathology. Although maltreatment ratings did not account for chronicity, this was primarily the result of the difficulty of verifying past reports that may have occurred in other states. In addition, older children may have longer abuse exposure, making it difficult to quantify chronicity. Nonetheless, specific aspects of maltreatment (e.g., type, chronicity, severity) may have influenced the results. For example, maltreated children with depression could have had greater maltreatment severity compared to maltreated children who did not have depression, which may have influenced their risk-taking behavior.

Future Research

The present study's results are preliminary and should be replicated in a larger sample. However, this study sets the stage for subsequent research examining reward-related processes in children, particularly those suffering from maltreatment and affective difficulties. Our goal is to use the WOF in the functional magnetic resonance imaging environment with clinical child populations to better understand the relationships between neural correlates of decision-making, psychopathology, and maltreatment. The strategy of linking reward-system perturbations with behavioral impairment permits a neuroscience systems–based approach to studying mechanisms underlying complex psychiatric disorders and using findings for developing effective psychotherapies (Ernst and Paulus, 2005). This strategy is particularly promising given the unique animal and human literature delineating neural correlates of the reward system (Di Chiara, 2002; Everitt et al., 2003)

Clinical Implications

The present findings may be relevant for clinical practice given the risk maltreated children face for developing disorders involving reward-related dysfunctions (e.g., substance use, depression/anhedonia). This sample may face further vulnerability given their developmental stage of adolescence, a period of changes in risk-taking and experimentation. Although these results are preliminary, given maltreated children's elevated risk of psychiatric disorders, clinical interventions may focus on assisting maltreated children with decision making and weighing consequences of potential outcomes. Behavioral therapy augmented with strategies for interpreting reward and punishment cues may help teach children to modulate their affective and motivational responses to such cues (e.g., thinking through outcomes for directed actions). Such interventions would need to be evaluated rigorously for their effectiveness in this population.

Disclosure: The authors have no financial relationships to disclose.

REFERENCES

Achenbach TM, Rescorla LA (2001), *Manual for the ASESBA School-Age Forms and Profiles*. Burlington: University of Vermont, Research Center for Children, Youth, and Families

Amaya-Jackson L, McCarthy G, Newman E, Cherney MS (1995), *Child and Adolescent PTSD Checklist*. Durham, NC: Duke University Medical Center

Amaya-Jackson L, Newman E, Lipschitz DS (2000), The child and adolescent PTSD Checklist in three clinical research populations. Paper presented at the Annual Meeting of the American Academy of Child and Adolescent Psychiatry, New York, October 24–29

Bernstein DP (1998), A new screening measure for detecting "hidden" domestic violence. Available at: http://www.psychiatrictimes.com/showArticle.jhtml?articleID=185301227. Accessed July 6, 2006.

Bernstein DP, Fink L (1998), *Childhood Trauma Questionnaire: A Retrospective Self-Report Questionnaire and Manual*. San Antonio, TX: The Psychological Corporation

Birmaher B, Khetarpal S, Brent D et al. (1997), The Screen for Child Anxiety Related Emotional Disorders (SCARED): scale construction and psychometric characteristics. *J Am Acad Child Adolesc Psychiatry* 36: 545–553

Breiter HC, Aharon I, Kahneman D, Dale A, Shizgal P (2001), Functional imaging of neural responses to expectancy and experience of monetary gains and losses. *Neuron* 30:619–639

Breslau N, Davis GC, Peterson EL, Schultz L (1997), Psychiatric sequelae of posttraumatic stress disorder in women. *Arch Gen Psychiatry* 54:81–87

Di Chiara G (2002), Nucleus accumbens shell and core dopamine: differential role in behavior and addiction. *Behav Brain Res* 137: 75–114

Dube SR, Felitti VJ, Dong M, Chapman DP, Giles WH, Anda RF (2003), Childhood abuse, neglect, and household dysfunction and the risk of illicit drug use: the adverse childhood experiences study. *Pediatrics* 111:564–572

Ernst M, Dickstein D, Munson S et al. (2004a), Reward-related processes in pediatric bipolar disorder: a pilot study. *J Affect Disord* 82:S89–S101

Ernst M, Nelson EE, Jazbec S et al. (2005), Amygdala and nucleus accumbens in responses to receipt and omission of gains in adults and adolescents. *Neuroimage* 25:1279–1291

Ernst M, Nelson EE, McClure EB et al. (2004b), Choice selection and reward anticipation: an fMRI study. *Neuropsychologia* 42:1585–1597

Ernst M, Paulus MP (2005), Neurobiology of decision-making: a selective review from a neurocognitive and clinical perspective. *Biol Psychiatry* 58:597–604

Everitt BJ, Cardinal RN, Parkinson JA, Robbins TW (2003), Appetitive behavior: impact of amygdala-dependent mechanisms of emotional learning. *Ann N Y Acad Sci* 985:233–250

Famularo R, Kinscherff R, Fenton T (1992), Psychiatric diagnoses of maltreated children: preliminary findings. *J Am Acad Child Adolesc Psychiatry* 31:863–867

Hasler G, Drevets WC, Manji HK, Charney DS (2004), Discovering endophenotypes for major depression. *Neuropsychopharmacology*

Heim C, Plotsky PM, Nemeroff CB (2004), Importance of studying the contributions of early adverse experience to neurobiological findings in depression. *Neuropsychopharmacology* 29:641–648

Henriques JB, Glowacki JM, Davidson RJ (1994), Reward fails to alter response bias in depression. *J Abnorm Psychol* 103:460–466

Kahneman D, Tversky A (1979), Prospect theory: an analysis of decision under risk. *Econometrica* 47:263–291

Kaufman J (1991), Depressive disorders in maltreated children. *J Am Acad Child Adolesc Psychiatry* 30:257–265

Kaufman J, Jones B, Stieglitz E, Vitulano L, Mannarino A (1994), The use of multiple informants to assess children's maltreatment experiences. *J Fam Violence* 9:227–248

Kendler KS, Bulik CM, Silberg J, Hettema JM, Myers J, Prescott CA (2000), Childhood sexual abuse and adult psychiatric and substance use disorders in women: an epidemiological and cotwin control analysis. *Arch Gen Psychiatry* 57:953–959

Kessler RC, Sonnega A, Bromet E, Hughes M, Nelson CB (1995), Posttraumatic stress disorder in the National Comorbidity Survey. *Arch Gen Psychiatry* 52:1048–1060

Koob GF, Le Moal M (2001), Drug addiction, dysregulation of reward, and allostasis. *Neuropsychopharmacology* 24:97–129

Leckman JF, Sholomskas D, Thompson WD, Belanger A, Weissman MM (1982), Best estimate of lifetime psychiatric diagnosis: a methodological study. *Arch Gen Psychiatry* 39:879–883

Masten CL, Schweder AE, Hodgdon HB et al. (2004), Effects of maltreatment and psychiatric diagnosis on identification of emotional facial expressions in children. In: *Society of Biological Psychiatry's Fifty-ninth Annual Convention and Scientific Program, April 29–May 1*. New York: Elsevier, p 123S

Matthews K, Robbins TW (2003), Early experience as a determinant of adult behavioural responses to reward: the effects of repeated maternal separation in the rat. *Neurosci Biobehav Rev* 27:45–55

Mellers BA, Schwartz A, Ho K, Ritov I (1997), Decision affect theory: emotional reactions to the outcomes of risky options. *Psychol Sci* 8:423–429

Naranjo CA, Tremblay LK, Busto UE (2001), The role of the brain reward system in depression. *Prog Neuropsychopharmacol Biol Psychiatry* 25:781–823

Nestler EJ, Barrot M, DiLeone RJ, Eisch AJ, Gold SJ, Monteggia LM (2002), Neurobiology of depression. *Neuron* 34:13–25

Paulus MP, Hozack N, Zauscher B et al. (2001), Prefrontal, parietal, and temporal cortex networks underlie decision-making in the presence of uncertainty. *Neuroimage* 13:91–100

Pelcovitz D, Kaplan S, Goldenberg B, Mandel F, Lehane J, Guarrera J (1994), Post-traumatic stress disorder in physically abused adolescents. *J Am Acad Child Adolesc Psychiatry* 33:305–312

Pine DS, Mogg K, Bradley BP et al. (2005), Attention bias to threat in maltreated children: implications for vulnerability to stress-related psychopathology. *Am J Psychiatry* 162:291–296

Pryce CR, Dettling AC, Spengler M, Schnell CR, Feldon J (2004), Deprivation of parenting disrupts development of homeostatic and reward systems in marmoset monkey offspring. *Biol Psychiatry* 56:72–79

Rasmusson AM, Charney DS (1997), Animal models of relevance to PTSD. *Ann N Y Acad Sci* 821:332–351

Sattler JM (1992), *Assessment of Children: Revised and Updated Third Edition*. San Diego: Sattler

Schweder AE (2003), Predictors of delinquent and aggressive behavior problems in maltreated children: a test of the diathesis-stress model. *Dissert Abstr Int B Sci Eng* 64:1527

Spear LP (2000), The adolescent brain and age-related behavioral manifestations. *Neurosci Biobehav Rev* 24:417–463

Strekalova T, Spanagel R, Bartsch D, Henn FA, Gass P (2004), Stress-induced anhedonia in mice is associated with deficits in forced swimming and exploration. *Neuropsychopharmacology* 29: 2007–2017

Tremblay LK, Naranjo CA, Graham SJ et al. (2005), Functional neuroanatomical substrates of altered reward processing in major depressive disorder revealed by a dopaminergic probe. *Arch Gen Psychiatry* 62:1228–1236

Wechsler D (1974), *Wechsler Intelligence Scale for Children-Revised (WISC-R)*. San Antonio, TX: The Psychological Corporation

Wood A, Kroll L, Moore A, Harrington R (1995), Properties of the mood and feelings questionnaire in adolescent psychiatric outpatients: a research note. *J Child Psychol Psychiatry* 36:327–334

Yehuda R (2004), Risk and resilience in posttraumatic stress disorder. *J Clin Psychiatry* 65:29–36

Epidemiology of DSM-IV Insomnia in Adolescence: Lifetime Prevalence, Chronicity, and an Emergent Gender Difference

Eric O. Johnson, PhD, Thomas Roth, PhD, Lonni Schultz, PhD, Naomi Breslau, PhD

Objective: The confluence of sleep/wake cycle and circadian rhythm changes that accompany pubertal development and the social and emotional developmental tasks of adolescence may create a period of substantial risk for development of insomnia. Although poor sleep affects cognitive performance and is associated with poor emotional and physical health, epidemiologic studies among adolescents have been limited. In this first epidemiologic study of insomnia defined by *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)* criteria in a US sample of adolescents, we estimated lifetime prevalence of insomnia, examined chronicity and onset, and explored the role of pubertal development. *Methods:* Data come from a random sample of 1014 adolescents who were 13 to 16 years of age, selected from households in a 400,000-member health maintenance organization encompassing metropolitan Detroit. Response rate was 71.2%. The main outcome measured was *DSM-IV*-defined insomnia. *Results:* Lifetime prevalence of insomnia was 10.7%. A total of 88% of adolescents with a history of insomnia reported current insomnia. The median age of onset of insomnia was 11. Of those with insomnia, 52.8% had a comorbid psychiatric disorder. In exploratory analyses of insomnia and pubertal development, onset of menses was associated with a 2.75-fold increased risk for insomnia. There was no difference in risk for insomnia among girls before menses onset relative to boys, but a difference emerged after menses onset. In contrast, maturational development was not associated with insomnia in boys. *Conclusions:* Insomnia seems to be common and chronic among adolescents. The often found gender difference in risk for insomnia seems to emerge in association with onset of menses. **Pediatrics** 2006;117(2):e247–e256.