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Maternal Cocaine Use and Infant Behavior

Rina Das Eiden
Research Institute on Addictions and Department of Pediatrics
State University of New York at Buffalo

Audra Lewis
Research Institute on Addictions and Department of Psychology
Vanderbilt University

Stacy Croff and Elizabeth Young
Research Institute on Addictions

This study examined the impact of maternal cocaine use and associated risk factors such as polysubstance use, maternal functioning, and caregiving on affect regulation during infancy. Participants were 45 mother–infant dyads (19 cocaine exposed and 26 control infants) recruited at birth. Observations and maternal reports of infant behavior were obtained at 2 and 7 months of age, along with measures of pre- and postnatal substance use, maternal functioning, and caregiving stability. Maternal cocaine use accounted for significant variance in infant positive affect at 2 months. Other substance use and gestational age predicted infant distress to novelty and arousal during developmental assessments. At 7 months, the impact of prenatal cocaine exposure on infant affect regulation was mediated by postnatal alcohol use and caregiving stability. These findings, if replicated, suggest that 1 pathway to later problem behavior reported among substance-exposed children may be through early regulatory problems and the quality of postnatal caregiving.

Maternal cocaine use during pregnancy has been described as a significant problem affecting large numbers of children. Although there is considerable consensus in the field regarding the impact of prenatal cocaine exposure on infant growth outcomes (Bateman & Chiriboga, 2000; Coles, Platzman, Smith, James, & Falek, 1992; Kuhn,

Requests for reprints should be sent to Rina Das Eiden, 1021 Main Street, Buffalo, NY 14203. E-mail: eiden@ria.buffalo.edu

Kline, Ng, Levin, & Susser, 2000), the results with other aspects of development have been mixed and somewhat inconsistent (see Lester, LaGasse, & Brunner, 1997). Indeed, potential cognitive outcomes among cocaine-exposed children have been the subject of rigorous study and debate in recent years, with reviews and meta-analyses suggesting that cocaine effects on these outcomes are subtle (Lester, LaGasse, & Seifer, 1998). At the same time, there is increasing recognition that cocaine may have significant influences on regulatory behavior. For instance, in their review, Lester et al. (1997) reported that of nine studies focusing on infant behavior as a function of cocaine exposure, seven reported significant group differences. Studies have also demonstrated that prenatal cocaine exposure is associated with lack of arousal-modulated attention independent of other risk factors (Karmel & Gardner, 1996).

Studies beyond the neonatal period indicate that cocaine exposure is likely to have lasting effects on regulation of arousal (Coles, Bard, Platzman, & Lynch, 1999; Mayes, Bornstein, Chawarska, Haynes, & Granger, 1996). Cocaine-exposed infants have increased behavioral reactivity and lability in response to novel stimulation and stress (Mayes et al., 1996; Mayes, Grillon, Granger, & Schottenfeld, 1998; Ramsay, Bendersky, & Lewis, 1996; Richardson, 1998). Moreover, prenatal cocaine exposure has been associated with attenuated cortisol response to stressful (e.g., inoculations and heel-stick procedures) and nonstressful but novel (e.g., developmental testing) situations (Magnano, Gardner, & Karmel, 1992; Ramsay et al., 1996). Other studies have reported lower overall arousal in novel situations, lower positive affect, and higher negative affect among cocaine-exposed infants (Alessandri, Sullivan, Imaizumi, & Lewis, 1993; Mayes et al., 1996). These behavioral data have been further supported by physiological data indicating that cocaine exposure contributes a significant amount of unique variance in arousal as measured by heart rate responses to stress (Bard, Coles, Platzman, & Lynch, 2000) and in response to novelty (Mayes et al., 1998). Moreover, toddlers and school-age children exposed to cocaine prenatally have poorer impulse control and higher behavioral problems compared to nonexposed children (Bendersky & Lewis, 1998; Chasnoff et al., 1998). Thus, prenatal cocaine exposure has some lasting effects on arousal and affect regulation in novel or somewhat stressful situations. The extent to which these effects are a result of the direct teratological impact of cocaine or are mediated by other risk factors associated with maternal cocaine use has not been well examined to date.

Primary among other risk factors is use of substances other than cocaine. Maternal cocaine use during pregnancy is associated with use of other substances such as alcohol, nicotine, and marijuana. Alcohol and nicotine in particular are known to have significant teratological influences on regulatory processes (Gingras & O'Donnell, 1998). Thus, the impact of maternal cocaine use can only be studied in the context of polydrug exposure and by measuring use of other substances in addition to cocaine.

Apart from other substances, two primary risk factors associated with cocaine use are negative maternal functioning (e.g., higher antisocial behavior and

psychological distress) and an inadequate caregiving environment. Recent studies have demonstrated the importance of examining the role of the caregiving environment in studies of cocaine-exposed infants. For instance, Coles et al. (1999) demonstrated that in addition to unique variance attributable to maternal cocaine use and preterm status, the quality of caregiving was a significant predictor of infant attentional responses as measured by heart rate. Another study with school-age children reported that the association between cocaine exposure and self-regulation was mediated by the quality of the home environment (Chasnoff et al., 1998). Finally, in a cross-sectional study of maternal substance use including cocaine and behavior problems among 3- to 5-year-olds, maternal substance use was indirectly associated with increased behavior problems through associations with caregiving instability (Eiden, 1999). Thus, the quality of caregiving environment is a critical predictor of child outcomes and is likely to be influenced by maternal substance use.

Along similar lines, the association between substance use and problematic psychological functioning has been well established. There is emerging recognition that one pathway to negative child outcomes may be through the association between maternal substance use and aspects of maternal functioning such as depression (Beckwith, Howard, Espinosa, & Tyler, 1999; Singer et al., 1997). Independent of substance use, several studies have demonstrated that maternal depression has a significant impact on maternal and infant behavior (Cohn & Campbell, 1992; Field, 1992). The impact of maternal depression on infant behavior is particularly salient among families experiencing multiple environmental risks (Campbell, Cohn, & Meyers, 1995; Seifer, Sameroff, Dickstein, Keitner, & Miller, 1996). Taken together, interactive models of development (Cicchetti & Luthar, 1999) and prior studies on prenatal cocaine exposure highlight the importance of examining both direct and indirect pathways to development among cocaine-exposed infants. Indirect pathways include the role of maternal psychological functioning and caregiving instability on infant behavior. Moreover, given the associations among cocaine, marijuana, alcohol, and cigarette use, the role of other substances also needs to be examined closely.

The purpose of this study was to examine the association between prenatal cocaine exposure and infant affect regulation at 2 and 7 months of age. Regulation was defined broadly as the infants' ability to regulate affect in response to novel stimulations. Thus, displays of positive and negative affect during affect-eliciting procedures and during developmental assessments were used as measures of regulation. Further, infant behavior in daily situations as measured by maternal reports was used to augment the measures of affect regulation in novel situations. It was hypothesized that cocaine-exposed infants would display more intense emotional reactions to stimuli as opposed to control infants across a variety of situations and measures (in laboratory paradigms, during developmental assessment, and through maternal reports). Cocaine-using mothers were expected to have higher psychological distress at 2 and 7 months of infant age and higher antisocial behavior.

Moreover, cocaine-exposed infants were expected to have greater caregiving instability by 7 months of age. These risk factors associated with maternal cocaine use were expected to mediate the association between frequency of maternal cocaine use during pregnancy and infant behavior. Exploratory analyses focused on the role of other substances like marijuana, cigarettes, and alcohol and the unique variance accounted for by maternal cocaine use.

METHOD

Sample

Mother–infant dyads were recruited from two inner-city hospitals after delivery. Originally, 53 mothers met inclusion criteria, 2 mothers in the control group refused to participate, and 6 mothers in the cocaine group were lost at 1-month assessment (we were unable to locate these mothers after they left the hospital). Thus, the final sample consisted of 45 mother–infant dyads[1] (19 cocaine-exposed infants and 26 control infants) who completed the 1-month, 2-month, and 7-month assessments. Mother–infant dyads were recruited at birth as part of a preliminary study of maternal substance use and infant social–emotional development. Mothers ranged in age from 19 to 43 ($M = 28.36$, $SD = 6.26$). There were 26 boys and 19 girls in this sample. The majority of mothers were African American (91%), receiving Aid to Families with Dependent Children (AFDC; 60%) at the time of recruitment (1998–1999), and were single (72%). All the mothers were the primary caregivers of their infants and had daily contact with them.

Prenatal cocaine-exposure status was determined by a combination of maternal report and chart review. Urine toxicologies from the prenatal or immediate postpartum period were available through chart review for all mothers in the study. Infants were considered cocaine exposed if maternal self-reports were positive regardless of urine toxicology results. Similarly, infants were also considered exposed if mothers reported that they did not use cocaine but the urine toxicology results were positive. Urine toxicologies consisted of standard urine screening for drug level or metabolites of cocaine, opiates, benzodiazepines, and tetrahydrocannabinol (THC). A urine was rated as positive if the quantity of drug or metabolite was less than 300 g/ml. Approximately 39% of mothers and infants in the cocaine group had positive urine toxicologies at delivery; the remainder of the mothers admitted having used cocaine in the brief, self-report screening instrument after delivery.

[1]Only 1 infant in the cocaine group was in a grandmother's custody; the mother was not involved in the infant's life. Thus, all assessments were conducted with the grandmother, and substance use information was obtained from the mother's medical charts. When analyses were conducted without including this dyad, the results were identical. Thus, results are presented with this dyad in the analyses.

Mothers were recruited into the control group if their urine toxicologies and self-reported substance use were negative for cocaine, they reported not using any illicit substances, and did not drink heavily during pregnancy (less than one drink a day or seven drinks a week). Additional exclusion criteria for all mothers consisted of the following: maternal age of 18 or younger, gestational age of less than 36 weeks, use of illicit substances other than cocaine or marijuana, and significant medical problems for the infant (e.g., genetic disorders, major perinatal complications, and baby in critical care for over 48 hr). The two groups were matched on maternal education. All mothers were paid for participation.

Procedure

All mothers were approached by study staff after delivery before they left the hospital, and were invited to participate in a study of maternal health and infant development. Interested and eligible mothers were given detailed information about the study and asked to sign consent forms. Names and addresses of at least three or four friends or relatives were noted to help locate the mothers and infants if their own address and telephone numbers (if available) were not sufficient. About 2 weeks after delivery, mothers were contacted and scheduled for their first laboratory visit. Mother–infant dyads were initially assessed at 1 and 2 months of infant age, with follow-up visits at 7 and 13 months of age. Infant height, weight, dysmorphia assessment, and assessment of behavioral asymmetries were conducted at 1 month of age, as well as maternal interviews regarding prenatal substance use, sensation seeking, and antisocial behavior. A developmental assessment and observations of mother–infant feeding interactions were conducted at 2 months of infant age, as well as maternal interviews regarding postnatal substance use, psychological symptoms, and reports of infant behavior. The visits at 7 and 13 months included measures of infant behavior in novel situations, developmental evaluations, mother–infant interactions, and maternal reports of infant behavior, postnatal substance use, and the caregiving environment. The 1-, 2- and 7-month data are reported in this article. Because of concerns about literacy, all measures were administered in an interview format.

Maternal substance use. The interview of maternal drug and alcohol use was adapted from two sources: the National Household Survey on Drug Abuse (Substance Abuse and Mental Health Services Administration, 1997), and the Maternal Health Interview, developed by Day and Robles (1989). All of the questions referring to alcohol and drug use during pregnancy were taken from the Maternal Health Interview, and the questions pertaining to postnatal substance use were taken from the household survey. These questions ask about patterns of drug use over pregnancy and the postnatal period, including information on types of drugs used, modes of use, and intensity of use. Measures of average daily ethanol intake (AA/day) and frequency of

cocaine and marijuana use during pregnancy and the postnatal period were derived from this interview. The majority of mothers in the cocaine group smoked crack cocaine or a combination of cocaine and marijuana or cocaine and tobacco. The frequency of cocaine use ranged from daily to one to two times during pregnancy, with the majority of mothers in the cocaine group smoking daily or almost daily (3–5 times a week). Number of years of cocaine use ranged from 1 to 15 ($M = 6.86$, $SD = 4.56$). Among the mothers in the cocaine group, 63% had been in treatment within the past year or were in treatment for substance abuse at the 1-month interview.

Maternal characteristics. The Antisocial Behavior Checklist (ASB; Zucker & Noll, 1980) was used in this study. The measure has been found to discriminate among groups with major histories of antisocial behavior (e.g., prison inmates, individuals with minor offenses in district court, and university students; Zucker & Noll, 1980), and between alcoholic and nonalcoholic adult men (Fitzgerald, Jones, Maguin, Zucker, & Noll, 1991). Parents' scores on this measure were also associated with maternal reports of child behavior problems among preschool children of alcoholics (Jansen & Oud, 1995). The original measure has adequate test–retest reliability (.91 over 4 weeks) and internal consistency ($\alpha = .93$). Maternal psychological symptoms were assessed using the Brief Symptom Inventory (BSI). The BSI (Derogatis, 1993) is a brief form of Symptom Checklist 90-R and is a widely used mental health screening measure in a variety of clinical and research settings. It consists of 53 items rated on a 5-point scale ranging from 0 (*not at all*) to 4 (*extremely*). The items are grouped into nine scales of Anxiety, Hostility, Somatization, Obsessive-Compulsive, Interpersonal Sensitivity, Depression, Phobic Anxiety, Paranoid Ideation, and Psychoticism. An overall score reflecting an average across all 53 items indicating a global severity index can also be obtained and was used in this study. The global severity index has been found to be a good general indicator of psychopathology among both men and women (Boulet & Boss, 1991).

Caregiving instability. Caregiving instability/inadequacy was assessed using a structured caregiver interview (Platzman, Coles, Bard, Brown, & Lynch, 2001). The Structured Clinical Interview (SCI) was developed for use with infants from 6 months to 24 months and has been used with two samples of cocaine-using mothers and their infants (Coles et al., 1999; Eiden, 1999). It was administered to the child's caregiver by a trained examiner blind to group status who subsequently scored certain items based on the information obtained to provide summary judgments in several areas of functioning. Items on the SCI can be evaluated individually or summed into a cluster called caregiving instability/inadequacy (Platzman et al., 2001). This cluster is theoretically based and consists of items known to be of significance for positive developmental outcomes and especially relevant for substance-using families (e.g., no adult male in household, baby separated from primary caregiver for more than 48 hr, baby is fed and sleeps significantly less than average, or baby does not see biological mother

regularly). The SCI has been found to be effective in demonstrating that there is greater caregiving instability/inadequacy among drug-using mothers (Eiden, Peterson, & Coleman, 1999; Platzman et al., in press). Furthermore, this dimension of caregiving instability/inadequacy was associated with an acceleratory heart rate response indicating distress or arousal among cocaine-exposed infants (Bard et al., 2000), and was a predictor of child behavior problems among 2- to 5-year-old children of cocaine-using mothers and matched control group children (Eiden, 1999).

Infant behavior. Rothbart's Infant Behavior Questionnaire (IBQ; Rothbart, 1981) was used to measure infant behavior at 2 and 7 months. The IBQ yields information about discrete categories of behavior and has been shown to have good internal consistency and discriminant validity (Goldsmith, Rieser-Danner, & Briggs, 1991; Goldsmith & Rothbart, 1991). The IBQ scales have also been found to be moderately associated with similar behaviors at home recorded by independent observers (Rothbart, 1986). The scale measures six dimensions of infant behavior: smiling and laughter, duration of orienting, soothability, distress to limits, activity level, and distress to novelty.

The IBQ was used in conjunction with four episodes from the Laboratory Assessment of Infant Temperament (LABTAB; Goldsmith & Rothbart, 1991) at 7 months of age. Two of these episodes measured positive affect (puppet show and cognitive assimilation), and the other two measured negative affect (arm restraint and toy retraction). All infants were exposed to the positive affect situations first. In the arm restraint episode, the child was allowed to play with an attractive toy for 15 to 30 sec, until the child was engaged with the toy. The caregiver was asked to stand behind the child, place her hands on the child's forearms, move them to the child's sides, and hold them there for 30 sec, while maintaining a neutral expression. After the first trial the caregiver was again asked to play with the child for 30 sec, followed by a second trial. The session was stopped if the child reached a maximum distress code or at the caregiver's request. The child was allowed to play with the toy at the end of the two trials. The toy retraction episode provided an opportunity for anger expression by interrupting toy exploration. The child was allowed to choose a toy and play with it for 15 sec, after which the caregiver was asked to gently slide the toy away from the child and place it out of his or her reach for 15 sec. The toy was then returned to the child, and the trial was repeated.

The puppet game measured positive affect in response to social stimulation using puppets for a standardized presentation. The game had a scripted dialogue that takes about 90 sec to present, followed by 30 sec during which the child was allowed to play with the puppets. The second positive affect episode consisted of the child playing with an age-appropriate pop-up toy. The toy was demonstrated to the child, followed by 120 sec of play with the toy. Following Goldsmith, Lemery, Buss, and Campos (1999), two composite scores were derived from these assessments: negative affect and positive affect. The negative affect score consisted of the standardized sum

of individual scores on latency to sadness or anger, intensity of sadness or anger, and intensity and duration of distress vocalizations. The positive affect scores consisted of the standardized sum of individual scores on latency to pleasure, frequency of smiling or laughter, and positive motor acts. Training in administration and coding of these paradigms was obtained from Goldsmith. Coders of all behavioral data were kept blinded with regard to group status and ratings of caregiving instability. Interrater reliability was assessed for 15% of the cases and ranged from .88 for negative affect to .92 for positive affect scores.

The final measure of infant behavior was derived from the Behavior Rating Scale (BRS), administered during a standard developmental evaluation (Bayley, 1993). The BRS measures infants' responses to the examiner throughout the testing situation as well as general behavioral state and lability of state of arousal. At 2 months, scores on two major factors can be derived: attention/arousal and motor quality. At 7 months, scores on three major factors can be derived: orientation/engagement (similar to the 2-month attention/arousal factor), emotional regulation, and motor quality. The attention/arousal factor measures the infants' state of arousal, positive and negative affect, soothability, and general interest in materials and social interaction. The orientation/engagement factor primarily measures the infants' affective state and interest and engagement with the materials and examiner. The emotional regulation factor measures infants' negative affect, task attention and persistence, and regulation of affect during transitions in testing materials. Interrater reliabilities on the BRS items were conducted on 15% of the cases from videotapes of Bayley administration and were as follows: .87 for 2-month attention/arousal factor, .80 for 2-month motor quality, .91 for 7-month orientation/engagement, .89 for 7-month emotional regulation, and .81 for 7-month motor quality. Taken together, it was anticipated that measuring infant behavior across these situations and through maternal report would result in a more accurate description of an individual infant compared to any one situation or measurement alone.

RESULTS

Demographic and Perinatal Data

Group differences on a variety of demographic and perinatal data are reported in Table 1. Analyses of variance (ANOVAs) indicated that mothers in the cocaine group were older, with a higher number of previous pregnancies, and their infants had lower gestational age, more obstetric complications, and smaller birth length. There were no group differences on birth weight, head circumference, dysmorphia score, or the number of prenatal visits. Chi-square analyses indicated that there were no group differences in marital status. Approximately 73% of mothers in the control group were single, compared with

TABLE 1
Means and Standard Deviation for Cocaine and Control Group Mothers and Infants on Demographic Perinatal Data and Substance Use Data

	Control		*Cocaine*		
Variables	*M*	*SD*	*M*	*SD*	*F*
Maternal age	26.04	5.18	31.53	6.34	10.20**
Parity	2.31	1.19	3.89	1.56	14.99**
Infant					
Gestational age	39.54	1.02	38.30	1.52	10.56**
Obstetric complications	108.38	16.42	92.32	11.70	13.24**
Birth weight (g)	3,361.00	504.00	3,132.00	655.00	1.76
Head circumference	33.81	1.63	33.14	6.86	0.22
Dysmorphia score	1.58	1.39	2.44	2.25	2.49
Birth length	50.61	2.48	45.98	7.44	8.79**
Number of prenatal visits	14.08	5.17	15.33	16.97	0.13
Pregnancy					
AA/day	0.006	0.002	0.80	1.97	4.23*
Frequency of binging	0.008	0.27	1.05	2.39	4.24*
Number of cigarettes/day	2.69	10.77	11.53	12.86	6.27*
Frequency of marijuana use	0.35	1.41	1.21	1.78	3.30***
Frequency of cocaine use	0.00	0.00	3.26	2.75	37.05**

Note. Frequency of marijuana- and cocaine-use responses were on a 7-point scale ranging from 0 (*never*) to 7 (*daily*).
*$p < .05$. **$p < .01$. ***$p < .10$.

79% single mothers in the cocaine group. Similarly, there were no differences between the two groups in the proportion of women receiving prenatal care (about 95% in the cocaine group and 100% in the control group). Correlational analyses examining the association between these demographic/perinatal variables and infant behavior at 2 and 7 months indicated that higher gestational age was associated with higher positive affect (maternal report) and more optimal arousal scores during developmental evaluation at 2 months of age ($r = .43, p < .01$; $r = .38, p < .05$, respectively). Higher gestational age was also associated with lower negative affect on the LABTAB at 7 months ($r = -.33$, $p < .05$). None of the other demographic or perinatal variables were associated with any of the infant behavior variables at either age. As a result, only gestational age was used as a covariate in further analyses.

Stability of Infant Behavior

Stability of infant behavior from 2 to 7 months was examined using correlational analyses. Results yielded few significant correlations across the same subscales,

with the exception of positive affect ($r = .39$, $p < .05$), activity level ($r = .30$, $p < .05$), and distress to limits ($r = .30$, $p < .05$) at 2 and 7 months. Thus, there was a moderate amount of instability in maternal ratings of infant behavior. However, arousal at 2 months was associated with maternal ratings of positive affect ($r = .32$, $p < .05$), and negative affect as measured by the LABTAB ($r = -.49$, $p < .01$). Distress to novelty at 2 months was associated with activity level ($r = .36$, $p < .05$), distress to limits ($r = .30$, $p < .05$), maternal ratings of positive affect ($r = -.43$, $p < .01$), engagement/orientation ($r = -.36$, $p < .05$), and emotion regulation ($r = -.34$, $p < .05$) at 7 months. Thus, these two aspects of infant behavior at 2 months were predictive of several aspects of infant behavior at 7 months in theoretically consistent ways.

Substance Use

Group differences on use of substances other than cocaine are presented in Table 1. As indicated, mothers in the cocaine group were significantly more likely to use other substances like alcohol, cigarettes, and marijuana. Only 2 mothers in the control group smoked marijuana (one used marijuana daily, the other used marijuana three to five times during pregnancy). Approximately 47% of mothers in the cocaine group smoked marijuana, with frequency ranging from one to two times during pregnancy to daily. Approximately, 73% of mothers in the control group did not use any alcohol during pregnancy, and 32% of the mothers in the cocaine group abstained from alcohol use during pregnancy. About 19% of mothers in the control group smoked during pregnancy, whereas about 89% of mothers in the cocaine group smoked during pregnancy. Thus, maternal cocaine use was accompanied by significant use of other substances like alcohol, cigarettes, and marijuana.

Maternal Characteristics and Caregiving Instability

Two aspects of maternal psychological functioning were measured in this study: maternal antisocial behavior and symptoms of psychological problems like depression and anxiety. Antisocial behavior was considered to be more of a trait and measured at 2 months. Psychological distress was considered to vary as a function of life stress and was measured at 2 and 7 months. Multivariate analysis of variance (MANOVA) was conducted with the two groups, control and cocaine as the independent variable, and the three maternal functioning variables as the dependent variables. There was a marginal multivariate effect of group status on maternal characteristics, $F(3, 41) = 2.44$, $p = .07$. Univariate analyses indicated a significant group difference on maternal antisocial behavior, with

TABLE 2
Means and Standard Deviations for Cocaine and Control Group on Maternal Characteristics, Caregiving, and Infant Behavior

	Control		*Cocaine*		
Variables	*M*	*SD*	*M*	*SD*	*F*
Maternal antisocial behavior	53.35	7.40	59.75	9.43	5.84*
Psychological distress (2 months)	24.85	29.67	24.22	19.75	0.00
Psychological distress (7 months)	25.81	25.18	29.76	22.35	0.23
Maternal sensation seeking	55.58	2.53	55.89	3.07	0.13
Caregiving instability	1.50	1.42	2.63	1.92	4.11*
2-month infant behavior					
IBQ positive affect	24.81	8.08	18.50	7.43	7.02**
IBQ duration of orienting	12.37	4.38	12.39	5.88	0.00
IBQ soothability	24.26	6.12	26.44	5.27	1.53
IBQ distress to limits	57.63	10.20	56.17	9.76	0.23
IBQ activity level	57.48	11.11	59.61	10.27	0.42
IBQ distress to novelty	11.74	5.45	16.28	7.44	5.58*
Behavior during testing:					
Arousal during testing	39.23	5.41	33.89	5.71	9.18**
Motor behavior during testing	34.50	0.91	33.78	1.48	3.59***
7-month infant behavior					
Engagement/orientation–testing	51.06	3.78	46.06	8.12	5.30*
Emotional regulation–testing	37.00	5.10	34.35	6.00	1.92
Motor behavior–testing	32.76	6.35	33.53	2.94	0.20
Positive affect–LABTAB	0.09	0.98	0.09	0.99	0.59
Negative affect–LABTAB	0.04	0.60	0.29	0.85	8.17**

Note. IBQ = Infant Behavior Questionnaire; LABTAB = Laboratory Assessment of Infant Temperament.
*$p < .05$. **$p < .01$. ***$p < .10$.

cocaine-using mothers reporting higher levels of antisocial behavior compared to control group mothers. Mothers in the two groups did not differ with regard to the number of psychological symptoms they experienced at either 2 or 7 months (see Table 2). One-way ANOVA was used to examine group differences on the instability of caregiving. This analysis indicated a significant group difference on caregiving instability, $F(1, 43) = 4.11, p < .05$, with children in the cocaine group experiencing greater instability in caregiving compared to children in the control group.

Correlational analyses were used to examine the associations between maternal characteristics/caregiving and infant behavior. Caregiving instability was associated with higher negative affect ($r = .42, p < .01$), lower engagement/orientation ($r = -.46, p < .01$), and poorer emotional regulation scores ($r = -.32, p < .10$) at 7 months. No other associations were obtained.

Group Differences in Infant Behavior

Two separate MANOVAs were conducted with all measures of infant behavior as the dependent variables at each age. At 2 months, these variables included the six subscales of the IBQ and the two subscales of the BRS as the dependent variables, and maternal group status as the independent variable.[2] This analysis yielded a significant multivariate effect of group status on infant behavior, $F(8, 36) = 3.04$, $p < .01$. Univariate analyses indicated that infants in the cocaine group displayed higher distress to novelty and lower positive affect compared to infants in the control group, according to maternal report. Furthermore, infants in the cocaine group displayed less optimal levels of arousal compared to those in the control group (see Table 2). When these analyses were repeated with infant gestational age as a covariate, the multivariate effect remained significant, with the univariate effects for distress to novelty and motor behavior also remaining significant. The univariate effect for arousal became marginal ($p < .10$), and the univariate effect for positive affect became nonsignificant, indicating that the association between maternal cocaine use and these aspects of infant behavior is accounted for by lower gestational age among cocaine-exposed infants.

Two separate MANOVAs were conducted at 7 months, one with the IBQ subscales and the second with the observations of infant behavior (LABTAB and BRS). Unlike the results at 2 months, there was no multivariate effect of group status on maternal reports of infant behavior at 7 months. However, there was a significant multivariate effect of group status on observations of infant behavior at 7 months, $F(5, 39) = 5.18$, $p < .01$. Univariate analyses indicated that cocaine-exposed infants displayed lower engagement/orientation during developmental assessment and higher negative affect during the laboratory stimulation episodes (see Table 2). These results remained unchanged with the addition of gestational age as a covariate.

Associations Between Substance Use/Other Risk Factors and Infant Behavior

Correlational analyses were used to examine the associations between substance use and other risk factors and infant behavior (see Table 3). These analyses indicated that frequency of cocaine, marijuana, cigarette, and alcohol use during pregnancy, as well as postnatal alcohol use at 2 months, were associated with less optimal arousal scores at 2 months. Higher maternal antisocial behavior was also associated with less optimal arousal scores. Number of cigarettes smoked during

[2]Results from MANOVA with group status as the independent variable and the Bayley Mental Development Index (MDI) and Psychomotor Development Index (PDI) scores as the dependent variables yielded no significant multivariate or univariate effects. Means for the MDI were 99.00 (SD = 9.45) and 94.82 (SD = 14.29), and for the PDI were 109.12 (SD = 5.86) and 105.06 (SD = 14.01) for the control and cocaine groups, respectively.

TABLE 3
Correlations Between Maternal Substance Use/Risk Factors and Infant Behavior

	Infant Behavior at 2 Months			*Infant Behavior at 7 Months*		
Substance Use and Other Risk Factors	*Arousal*	*IBQ Distress to Novelty*	*IBQ Positive Affect*	*Engagement/ Orientation*	*Emotional Regulation*	*Negative Affect*
Pregnancy						
Cocaine use	−.34*	.37**	−.37**	−.35*	−.24	.33*
Marijuana use	−.31*	.15	−.21	−.22	−.19	.22
AA/day	−.37**	.09	−.08	.00	−.13	.24
Cigarettes	−.35*	.36**	−.13	−.11	−.13	.36**
2 Months						
AA/day	−.34*	.14	.05	−.12	−.12	.29*
Psychological distress	−.09	.08	.11	−.20	−.11	−.13
Antisocial behavior	−.30*	.23	−.08	−.12	.04	.19
Sensation seeking	−.03	−.18	.02	.17	.18	−.04
7 Months						
AA/day	—	—	—	−.47**	−.44**	.10
Psychological distress	—	—	—	−.32*	−.31*	−.04
Caregiving instability	—	—	—	−.25	−.46**	.47**

Note. IBQ = Infant Behavior Questionnaire.
*$p < .05$. **$p < .01$.

pregnancy was associated with higher distress to novelty at 2 months, and higher negative affect at 7 months. Amount of postnatal alcohol use at 7 months was associated with lower levels of engagement/orientation and less optimal emotional regulation at 7 months. Finally, maternal psychological distress at 7 months was associated with infant behavior during testing, and caregiving instability at 7 months was associated with emotional regulation and negative affect.

Unique Variance Associated With Cocaine Use

Given that cocaine use was associated with heavier use of other substances, the next step was to examine if cocaine accounted for unique variance in infant behavior after controlling for use of other substances. Regression analyses were used, and criterion variables were those associated with frequency of cocaine use (arousal, distress to novelty, and positive affect at 2 months, engagement/orientation and negative affect at 7 months). For the 2-month infant-behavior variables, these analyses indicated that frequency of maternal cocaine use did not account for unique variance in arousal or distress to novelty. Maternal cocaine use did account for unique variance in infant positive affect at 2 months after controlling for other substance use (see Table 4). At 7 months, maternal cocaine use did not

TABLE 4
Prediction of Infant Behavior at 2 Months: Unique Variance Associated With Frequency of Cocaine Use

				Standardized Regression Coefficients	
Predicting Arousal at 2 Months	R^2	R^2Inc	*FCh*	*Step 1*	*Step 2*
Predictor variables					
1. AA/day—pregnancy				−.36**	−.32*
Number of cigarettes				−.19	−.10
Frequency of marijuana use				−.18	−.18
AA/day—2 months	.23	.23	2.48***	−.18	−.13
2. Frequency of cocaine use	.25	.02	0.90		−.18
Predicting distress to novelty at 2 months					
1. AA/day—pregnancy				−.08	−.20
Number of cigarettes				.33*	.25
Frequency of marijuana use				.07	.01
AA/day—2 months	.14	.14	1.50	.11	.18
2. Frequency of cocaine use	.20	.06	2.84***		.29***
Predicting positive affect at 2 months					
1. AA/day—pregnancy				−.29+	−.13
Number of cigarettes				−.12	−.01
Frequency of marijuana use				−.18	−.09
AA/day—2 months	.11	.11	1.17	−.21	−.11
2. Frequency of cocaine use	.19	.08	3.67*		−.39*

*$p < .05$. **$p < .01$. ***$p < .10$.

account for unique variance in engagement/orientation, but did account for unique variance in negative affect in response to stress (see Table 5).

Mediational Analyses

To test the hypothesis that maternal characteristics or caregiving instability would mediate the association between cocaine use and infant behavior, mediator analyses were conducted following Baron and Kenny's (1986) guidelines. According to Baron and Kenny (1986), the steps in mediational analyses are as follows: the predictor (cocaine) and mediator variables (described earlier) should be associated, the mediator and criterion variables should be associated, and the predictor should be associated with the criterion (infant). In the last step, both the predictor and the mediator should be regressed on the criterion, the association between the predictor and the criterion should be reduced, and the addition of the mediator should account for significant improvement in prediction.

Given the pattern of associations reported in Table 3 and the unique contribution of maternal cocaine use reported in Tables 4 and 5, only one infant-behavior variable met the first two criteria for mediation: infant negative affect as measured by the LABTAB at 7 months. Frequency of cocaine use accounted for unique variance in negative affect. Caregiving instability was also associated with negative affect. Moreover, frequency of cocaine use and caregiving instability were associated with each other.

The last criteria for mediation states that the association between the predictor and the criterion should be reduced once the mediator is entered into the regression

TABLE 5
Prediction of Infant Behavior at 7 Months: Unique Variance Associated With Cocaine Use

				Standardized Regression Coefficients	
Predicting Engagement/Orientation	R^2	R^2Inc	*FCh*	*Step 1*	*Step 2*
Predictor variables					
1. AA/day—pregnancy				−.19	−.24
Number of cigarettes				−.06	−.01
Frequency of marijuana use				−.13	−.10
AA/day—2 months				.08	.03
AA/day—7 months	.30	.30	2.20***	−.57**	−.52**
2. Frequency of cocaine use	.31	.01	0.28		−.13
Predicting negative affect					
1. AA/day—pregnancy				−.09	−.25
Number of cigarettes				.31	−.15
Frequency of marijuana use				.03	.09
AA/day—2 months				.29	.48**
AA/day—7 months	.19	.19	1.25	.01	.25
2. Frequency of cocaine use	.44	.25	11.48***		.60**

*$p < .05$. **$p < .01$. ***$p < .10$.

TABLE 6
Prediction of Infant Negative Affect in Response to Stress at 7 Months

				Standardized Regression Coefficients		
Predictor Variables	R^2	R^2Inc	*Fch*	*Step 1*	*Step 2*	*Step 3*
1. Gestational age	.12	.10	4.18*	−.34*	−.32*	−.28***
2. Caregiving instability	.35	.23	11.04**		.48**	.46**
3. Frequency of cocaine use	.37	.02	0.79			.14

*$p < .05$. **$p < .01$. ***$p < .10$.

equation. Accordingly, gestational age was entered in the first step as a covariate, caregiving instability was entered in the second step, and frequency of cocaine use was entered in the last step. As depicted in Table 6, caregiving instability accounted for a significant improvement in prediction, and the association between the predictor (cocaine use) and criterion (negative affect) was significantly reduced with caregiving instability in the equation. Thus, the association between cocaine use and negative affect at 7 months was completely mediated by caregiving instability.

DISCUSSION

The results of this study indicate that maternal cocaine use has some direct and indirect implications for infant regulatory behavior. Infant behavior at 7 months was not associated with maternal cocaine use per se, but with maternal cigarette smoking, postnatal alcohol use, and caregiving instability. Thus, one pathway to later regulatory problems among cocaine-exposed infants seems to be through the quality of the postnatal environment. These results are consistent with previous studies reporting that cocaine-exposed infants are more likely to experience exposure to multiple substances and higher caregiving instability, and that these risk factors associated with cocaine exposure are directly associated with regulatory problems in early infancy and behavior problems in later childhood (Coles et al., 1999; Eiden, 1999; Eiden et al., 1999). Future studies with larger sample sizes are needed to examine issues of heterogeneity within the group of cocaine-exposed infants. It is possible that infants experiencing regulatory dysfunction in early infancy and exposed to problematic postnatal care are most at risk for later dysfunction. Results from this and previous studies all contribute to the idea that the impact of prenatal cocaine exposure can only be examined in the context of other substance use and by examining the quality of the postnatal environment.

Cocaine seems to account for unique variation in some aspects of infant regulation at 2 months of age, namely, the display of positive affect in everyday situations. However, infant positive affect at 2 months was measured only by maternal report. It is possible that mothers using cocaine were more likely to perceive their infants in a less positive light compared to non-cocaine-using mothers. Maternal perceptions of lower positive affect are likely to influence maternal interactions with the infant and increase risk for poor infant outcomes. On the other hand, maternal perceptions may reflect the reality that these infants do not display positive affect as frequently and across situations compared to non-cocaine-exposed infants.

Indeed, the association between maternal cocaine use and lower positive affect was augmented by observations of infant behavior during developmental assessments. These observations suggested that cocaine-exposed infants displayed less

optimal arousal (behavioral state, positive and negative affect, soothability, and general interest in materials and social interaction), and this association was mediated by other substance use and lower gestational age. The association between cocaine and less optimal arousal at 2 months has been reported by other studies using more refined measures of arousal (changes in heart rate on encountering a novel stimulation; Bard et al., 2000). Studies using animal models have also reported differences in stress responsiveness as a function of prenatal cocaine exposure, lending further support to the findings from this study (Johns & Noonan, 1995; Wood, Molina, Wagner, & Spear, 1995). It is worth noting that arousal as measured during developmental assessments primarily refers to regulation of affect and behavior during social interactions and interactions with novel stimuli. Problems with arousal during social and novel interactions may have significant implications for later functioning and may be one pathway toward risk for regulatory dysfunction reported among substance-exposed children. Indeed, nonoptimal arousal at 2 months was associated with higher negative affect as measured by the LABTAB and lower positive affect on the IBQ at 7 months. This is an area for future research.

One surprising result from this study was that while maternal cocaine use was associated with maternal reports of infant behavior at 2 months, there were no associations with maternal reports at 7 months. Maternal reports of infant behavior at 7 months were also not associated with the quality of caregiving. Furthermore, the associations between maternal reports at 2 and 7 months were sporadic and not very high when they did exist, and there were few associations between maternal reports at 2 months and behavioral observations at 2 or 7 months. This is contrary to other studies reporting much higher stability in infant behavior across time and higher associations between maternal report and behavioral observations (see Bridges, Palmer, Morales, Hurtado, & Tsai, 1993). One explanation for results in this study may be that this high-risk group experienced greater instability in behavior due to higher instability in the environment. These results need to be replicated with larger samples.

Apart from small sample size that limits an examination of moderating influences and limits generalizability, there are several additional limitations in this study. Infant regulatory behavior was measured across a number of different situations and measures, but it did not include any direct measures of physiological regulation. Lack of a large enough sample size made the possibility of examining the impact of postnatal cocaine use more difficult, given that only 3 mothers in the cocaine group reported using cocaine postnatally. Moreover, a longitudinal follow-up with similar measures across at least three time points would allow for assessments of changes across time in infant regulatory behavior as well as predictors of those changes. One hypothesis that needs further investigation is that infants of cocaine-using mothers display increasing regulatory problems over time.

In conclusion, this study provides further support to the small body of literature suggesting that whereas the impact of maternal cocaine use in the context of

polydrug use may have subtle effects on mental development, it may have a more significant impact on regulatory behavior. Group differences in behavior may be a function of both initial regulatory problems as well as the quality of the postnatal environment. Indeed, the finding that at 7 months, the impact of cocaine on infant regulatory behavior is entirely mediated by postnatal substance use and caregiving stability has some implications for intervening with this high-risk population. Future studies with larger sample sizes and longer follow-up points are needed to examine these questions in more detail.

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