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Longitudinal Effects of Prenatal Cocaine Use on Mother-Child Interactions at Ages 3 and 5

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Abstract

Objective—To assess the effect of maternal prenatal and past-year cocaine use on mother-child interactions across the preschool years.

Methods—The sample is drawn from the Miami Prenatal Cocaine Study (MPCS), a longitudinal follow-up of prenatal cocaine exposure (PCE) in a large cohort of African-American infants prospectively enrolled at birth. Analyses are based on the 366 children (168 PCE and 198 NCE) in the care of their biological mothers and with completed mother-child interaction measures at the 3- and/or 5-year assessments. Videotaped interactions were coded using a modified Egeland Teaching Task scheme. GLM/GEE models were used to evaluate the effect of PCE on the overall quality of maternal-child interaction, measured by the Egeland total score at both study visits, and on the individual Egeland subscales at the 5-year visit, while adjusting for other suspected influences on interactions.

Results—PCE dyads demonstrated less optimal overall mother-child interactions compared to NCE dyads. The estimated PCE-associated difference did not shift appreciably with statistical adjustment for child sex, child age at exam or other birth covariates. PCE dyads with past-year maternal cocaine use had significantly lower Egeland summary scores compared to children with neither exposure. In subscale analyses, PCE was most strongly associated with greater maternal intrusiveness and boundary dissolution at the 5-year visit.

Conclusions—Prenatal and past-year maternal cocaine use appear to be associated with poorer quality in mother-child interaction during early childhood. These dynamics should be considered when examining the association between prenatal cocaine exposure and child cognitive, behavioral, and academic outcomes.

Keywords

prenatal; cocaine; exposure; mother-child; interaction

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INTRODUCTION

Significant concerns have been raised regarding the impact of prenatal drug exposure and ongoing maternal drug abuse on parental functioning and maternal-child interaction. Mothers who use cocaine while pregnant have a tendency to abuse additional substances including alcohol, marijuana, and tobacco,¹ and many continue to use drugs after delivery. These mothers typically reside in high-risk environments characterized by low-income communities, inadequate nutrition, ongoing familial substance use, homelessness and minimal social support.^{2,3} Maternal drug abuse combined with contextual risk factors may exacerbate maternal stress which can compromise the quality of parenting and mother-child interactions.

Studies have found that mothers who use cocaine and other drugs are often less attentive and responsive, more intrusive, provide inadequate infant stimulation, and display greater hostility and insensitivity during parent-child interactions.^{1,4-6} Tronick et al.⁷ revealed that mothers who used cocaine during pregnancy exhibited more negative engagement behaviors and affective states inconsistent with their infants more frequently than mothers of non-exposed infants during a play and still-face interaction. Additionally, prenatally cocaine-exposed infants displayed increased levels of social monitoring compared to non-exposed infants. LaGasse and colleagues⁴ reported that mothers who used cocaine prenatally were less engaging and less flexible during feeding and terminated feeding sessions earlier than mothers who did not use illicit substances. Other studies have not demonstrated a relationship between prenatal substance use and parenting deficits.^{8,9} Neuspiel et al.⁸ found no significant cocaine-associated differences in maternal sensitivity and responsiveness during infant feeding, although this study was limited by sample attrition and absence of toxicology in the majority of comparison subjects. Uhlhorn, Messinger, and Bauer⁹ also found no prenatal cocaine-related effects on maternal sensitivity and dyadic responsiveness during play between mothers and their toddlers. Variation in sample characteristics and methodological issues such as sample size, power, and assessment method may account for inconsistencies across study findings.

Women who use drugs during pregnancy are more likely to exhibit comorbid psychopathology, including anxiety and depressive symptoms and personality and post-traumatic stress disorders.^{1,3,10} Studies demonstrate that mothers with both substance abuse and psychopathology are less able to understand and respond sensitively to their infants' cues compared to mothers with substance abuse alone.^{3,10} The presence of severe paranoid and depressive symptoms among substance-using mothers not only negatively impacts the quality of parenting but is also associated with decreased functioning among prenatally substance-exposed infants.¹⁰ The cumulative impact of prenatal and postnatal cocaine use on early mother-child interactions has also been investigated. In an intervention study, Schuler et al.¹¹ found that ongoing maternal cocaine and/or heroin use and rigid parenting attitudes predicted decreased maternal competence during mother-child play interactions at 18 months postpartum. In another study, Eiden et al.¹ revealed that continued cocaine use postpartum among mothers with depression and/or anxiety was a significant predictor of greater maternal insensitivity and negative parenting behaviors during feeding interactions with their 4- to 6-week old infants.

Although research suggests that mothers who use drugs during and after pregnancy are at increased risk for maladaptive parent-child interactions during infancy, there are significant gaps in the literature. Few studies have examined maternal-child interactions longitudinally during the preschool years and even fewer have assessed these relationships among children with prenatal cocaine exposure (PCE). Findings from our prior research indicated that PCE negatively impacted overall mother-child interaction during play at age 3. Specifically,

findings revealed greater maternal intrusiveness and hostility, poorer quality of instruction, lower maternal confidence, and diminished child persistence in PCE compared to non-cocaine exposed (NCE) mother-child dyads at age 3 years. Overall quality of maternal-child interaction was most impaired among children with both PCE and ongoing maternal cocaine use compared to NCE children whose mothers did not report continued cocaine use.¹² The purpose of this study is to extend our previous work to assess the longitudinal effect of maternal cocaine use on mother-child interactions at age 3 and age 5. It was hypothesized that prenatal maternal cocaine use would be associated with poorer quality of maternal-child interaction during early childhood, and the effect would be stronger among those PCE dyads where mothers also reported past-year cocaine use compared to NCE mother-child dyads. It was also hypothesized that these effects would be evident at both the 3- and 5-year follow-up visits.

METHODS

Study Design

The Miami Prenatal Cocaine Study (MPCS) is a multi-wave longitudinal study examining the impact of *in utero* cocaine exposure on neurodevelopmental outcomes. Participants were recruited from deliveries of full-term, inner-city, African-American infants born between November 1990 and July 1993 at the University of Miami Jackson Memorial Medical Center. The overall study design and enrollment procedures for the MPCS, briefly summarized below, have been detailed in an earlier report.¹³

Study Participants

The original MPCS sample included 476 full-term infants enrolled prospectively at birth and categorized into either PCE (n=253) or NCE (n=223) groups. PCE infants were also exposed to varying combinations of alcohol, tobacco and marijuana. Of the 223 NCE infants, 76 were exposed to varying combinations of alcohol, tobacco and marijuana and 147 were drug-free. The study cohort was relatively homogenous with respect to full-term gestational age (≥ 37 completed weeks), low socioeconomic status, inner-city residence and African American race/ethnicity. Exclusion criteria consisted of < 37 weeks gestational age, maternal HIV/AIDS; prenatal opiate, methadone, phencyclidine, amphetamine, barbiturate, or benzodiazepine exposure; chromosomal abnormality; major congenital malformation; or disseminated congenital infection. PCE was determined by maternal self-report of any cocaine use during pregnancy and/or positive assay on one or more biological markers (i.e. maternal urine, infant urine, and meconium) at delivery. Alcohol and tobacco exposures were determined by self-report, and marijuana by self-report and/or a positive toxicology screen. Drug-free mothers had negative self-report histories of substance use during and three months preceding pregnancy, negative lifetime histories of cocaine use, and negative findings on all available toxicology screens.

The current report focuses on the impact of PCE on maternal-child interactions at ages 3 and 5 years. Cohort retention was 439 (92%) and 415 (87%) at the 3- and 5-year assessments, respectively. Data analyses are based on a subsample of the original cohort that includes only the children (n=366; 168 PCE and 198 NCE) with at least one parent-child interaction completed with the biological mother at the 3 and/or 5-year visits (281 completed interactions with the biological mother at both visits; 62 at the 3-year only; 23 at the 5-year only). Seventy-four children were excluded because they did not have a completed parent-child interaction with the biological mother at either exam, and an additionally 3 children were excluded due to missing data because of videotaping/coding problems. PCE children were less likely than NCE children to be included in the study subsample (66% vs. 89%, $p < 0.001$) as they were less likely to be in the primary care of their biological mother at the

follow-up visits. The sample was restricted to biological mothers since approximately 30% of the children with PCE (compared to approximately 5% of the NCE children) were in diverse foster care or kinship care environments, and this group difference may have a confounding influence on study results. In addition, one aim of the study was to evaluate the effects of PCE in the context of continued maternal cocaine use which is most pertinent for the biological mothers in the sample.

A comparison of birth characteristics between those included in the study subsample (n=366) and those excluded (n=110) revealed no differences in infant sex, birth head circumference, maternal education, employment, marital status, or self-reported amounts of crack/cocaine, alcohol, tobacco, or marijuana during pregnancy (all $p>0.05$). Mothers included in the present study were younger at delivery (26 vs 28; $p=0.007$), had infants with higher birth weight (3159 vs 3018; $p=0.012$) and length (50 vs 49; $p=0.001$), were more likely to be first time mothers (17% vs 6%; $p=0.007$), and had attended a greater number of prenatal care visits (80% vs 61%; $p<0.0001$) than those excluded.

Classification of Prenatal Drug Exposure

Maternal Interview—Maternal interviews were conducted within 36 hours following delivery. Standardized substance use questions were administered to assess the pattern and severity of drug and alcohol use before and during pregnancy by trimester. Daily dosage was measured in number of cigarettes smoked, number of marijuana joints smoked, number of alcoholic beverages consumed including beer, wine and/or hard liquor, and number of cocaine lines/rocks used. Standard classifications were used to define 1-drink units for each type of alcohol consumed (beer 12 oz., wine 5 oz., and liquor 1.5 oz.). Total pregnancy self-report composites were calculated for each drug by multiplying the number of weeks used by the usual number of days per week by the usual dose per day. Exposure composites for alcohol, tobacco, and marijuana were utilized as covariates in the analyses. A dichotomous prenatal cocaine exposure variable (yes/no) based on self-report and biological markers was used to identify group assignment (PCE or NCE) and evaluate group differences in mother-child interactions.

Biological Markers (Urine and Meconium)—Maternal and infant urine and meconium were screened for cocaine metabolite (benzoylecgonine) using EMIT® (Syva D.A.U.), at a cut-off of 150 ng/ml urine and 150 ng/gm meconium, respectively. Cocaine-positive specimens were confirmed by gas chromatography/mass spectrometry (GC/MS).¹⁴ EMIT® and GC/MS confirmation were also used to assay urine for marijuana (cannabinoids), opiates, amphetamines, barbiturates, benzodiazepines, and phencyclidine; and to screen meconium for cannabinoids, and opiates. In the original sample, 100% had at least 1 biological marker, 96% had at least two, and 68% had all three markers.

Postnatal Caregiver Measures

A structured psychosocial interview assessing family composition, caregiver changes, family moves, support services and other relevant psychosocial information during the previous year was administered to the mother/primary caregiver during the 3- and 5-year assessments. Past-year maternal cocaine, alcohol, tobacco, and marijuana use was assessed at the 3-year visit via a standardized interview similar in format to the birth interview; at the 5-year visit, maternal drug use was assessed in the context of the Addiction Severity Index (ASI)¹⁵ modified to include frequency of past-year use. The Symptom Checklist-90-R (SCL-90-R)¹⁶ was completed by the mother during the 3- and 5-year visits. The SCL-90-R Global Severity Index (GSI) was used in analyses as an indicator of overall maternal psychological distress.

Assessment Procedures

Mother-child interaction tasks were administered as part of comprehensive child and caregiver assessments at the 3- and 5-year follow-up visits. Trained research staff blind to prenatal and past-year drug exposure status provided the mother with instructions prior to the initiation of the tasks and observed and videotaped the interaction for later coding.

Mother-Child Semi-Structured Free-Play Interaction (Age 3 Years)—During the 3-year visit, mother-child dyads completed a 15-minute session in which the mother was instructed to play with her child as she typically does at home. Age-appropriate toys were provided to stimulate spontaneous reciprocal interactions.

Mother-Child Structured Teaching Tasks Interaction (Age 5 Years)—At the 5-year visit, the mother and child completed a 25-minute videotaped interaction involving 5 interactive structured teaching tasks assessing the child's ability to regulate behavior during a challenge and the mother's ability to provide appropriate support, assistance, and scaffolding of the child's efforts. The mother was instructed to allow the child to try to solve the task, but to provide assistance when needed. The tasks were: 1) to read or look at a children's book and then discuss the story with her child; 2) to teach her child how to build a tower out of small blocks; 3) to instruct her child to name as many different objects with wheels as possible; 4) to have her child put blocks into a shape sorter in the correct spaces; and 5) to have her child trace a maze pattern drawn on an Etch-A-Sketch. At the beginning of each task, mothers were reminded about how to perform the task and were notified when it was time to discontinue each activity.

Mother-Child Interaction Coding

Teaching Tasks Coding Scheme—A modified version of the Egeland Teaching Task coding scheme¹⁷ was used to score the videotaped mother-child interactions at both the 3- and 5-year visits. This coding system, conceptualized from Bowlby's theory of attachment, has been supported for use with minority and high-risk mother-child dyads.¹⁸ It is observation-based and focuses on the mother-child dyad's ability to work together and adapt to each other's needs to achieve a desired goal.¹⁷ The coding scheme consists of 14 rating subscales. Five subscales assess the mother's behavior: supportive presence, intrusiveness, hostility, quality of instruction, and confidence. Seven subscales assess the child's behavior: persistence, enthusiasm, negativity, compliance, experience of the session, affect toward mother, and avoidance of the mother. Two subscales assess dyadic interaction: quality of the relationship and boundary dissolution (See Table, Supplemental Digital Content 1, which provides detailed descriptions of the Egeland rating subscales).

A doctoral level researcher trained and supervised research assistants to code the videotaped mother-child interactions at age 3 and age 5 using the Egeland et al coding scheme. Intra-class correlation coefficients for the 13 interval-scaled codes at the 3-year visit ranged from 0.69 to 0.91 (mean intra-class coefficient = 0.82). Kappa for the single categorical-type item, maternal confidence, was 0.36. Reliability coefficients were comparable with those reported in the Teaching Task coding manual and previously published manuscripts.¹²

Statistical Analyses

Exploratory factor analyses were conducted on the 14 Egeland subscales separately at ages 3 and 5. At age 3, model fit statistics and eigenvalues (Factor 1 Eigenvalue = −6.94; Factor 2 Eigenvalue = 0.86) supported a unidimensional latent structure. Overall Cronbach alpha was >0.90 and item-metric analysis indicated all $\alpha \geq 0.90$ when items were removed one by one. Evidence from the age 3 data informed the analyses of age 5 Egeland item-level data, which again fitted a unidimensional latent structure (Factor 1 Eigenvalue = 6.6; Factor 2

Eigenvalue = 1.0; Factor 3 Eigenvalue = .55). Although a second factor could be justified with an eigenvalue of 1.0, there was no theoretical rationale in favor of a two-factor model. Hence, the more parsimonious unidimensional model was chosen. The overall and item-omitted Cronbach alpha values for the factor was at ≥ 0.90 . At each time point, individual Egeland items were summarized via a factor score which is an indicator of overall parent-child interaction quality. Tukey's ladder of powers implemented under Stata software disclosed no advantage to transformation of the already Gaussian distribution of the resulting unidimensional composite index.

A generalized linear model and generalized estimating equation method (GLM/GEE)¹⁹ was utilized to estimate the effects of PCE on the quality of mother-child interaction. The GLM/GEE approach to longitudinal data analysis was selected because it utilizes all available data and does not impose compound symmetry assumptions. GLM/GEE models were initially used to estimate the effect of PCE on the Egeland, borrowing information across 3- and 5-year summary scores with successive introduction of covariate terms for variables that might influence the quality of mother-child interaction. The borrowing approach refers to a multivariate response regression model, with a subscript on the y-variable to keep track of the two measurement values (i.e., Egeland summary score at age 3 and at age 5). With this GLM/GEE approach, the most parsimonious model is one that yields a single regression slope estimate of the effect of PCE on the Egeland summary score, suggesting that the PCE effect has the same size and sign whether the age 3 or the age 5 Egeland values are considered. In this "single slope" model, information is in effect 'borrowed' across Egeland 3- and 5-year values to derive a single estimate of the PCE effect on the quality of mother-child interaction.

The GLM/GEE model was then revised to examine whether PCE might have a differential influence upon some facets of mother-child interaction. This GLM/GEE multivariate response profile model provides a simultaneous estimation of the effects of PCE on the 14 Egeland subscales, with consideration for inter-dependencies as might exist among the subscales. In this report, the estimated effects of GLM/GEE estimates are expressed as regression slope coefficients with 95% confidence intervals (CI); p-values are presented as an aid to interpretation.

RESULTS

Sample Demographics

Table 1 presents the maternal and infant characteristics of the study subsample (n=366) at birth enrollment. Cocaine-using mothers were older, less often employed, had higher gravidity, and utilized less prenatal care than non-cocaine-using mothers. PCE infants were smaller in birth weight, length and head circumference and had lower gestational age than NCE infants. Table 2 summarizes the amount of prenatal alcohol, tobacco, marijuana, and cocaine use reported by the mothers in each group. A higher percentage of cocaine-using mothers reported prenatal use of alcohol, tobacco, and marijuana. Cocaine-using mothers also smoked a greater median number of cigarettes than non-cocaine-using mothers.

Amounts of cocaine use were also characterized by trimester based on self-report (data not shown in table) with 52% reporting use the 1st trimester only, 41% during the 1st and 2nd trimesters and 27% during all three trimesters. Notably, while only 41% of cocaine-using mothers self-reported cocaine use in the 3rd trimester, 80% has a positive toxicology at delivery suggesting that self-reported cocaine use during the 1st and 2nd trimesters is likely an underestimate.

Table 3 shows maternal and child characteristics of the study subsample at the follow-up visits. Mothers who used cocaine during pregnancy had less education (at the 5-year visit only), were more often unemployed, and were more likely to self-admit past-year use of cocaine, tobacco, and marijuana compared to non-cocaine-using mothers. Compared to PCE children, NCE children were slightly older at assessment (3-year visit only), experienced fewer caregiver changes through age 5, were less likely to have blood lead levels $\geq 10\text{ng/dL}$, and were more likely to have attended preschool or Head Start. There were no group differences in child global cognitive functioning at the 3- and 5- year assessments.

Longitudinal Multivariate Analyses

A series of longitudinal GLM/GEE models, presented in Table 4, were conducted to estimate the hypothesized PCE-associated differences in the quality of mother-child interaction. A 'single slope' or 'common slope' model was used as the size (and sign) of the PCE effect estimate did not differ appreciably across the two time points (as indicated by a PCE*Time product-term p-value of 0.354). Model 1 provides a baseline estimate of this PCE-associated difference. Comparing PCE and NCE dyads, the estimated between-group difference in mean Egeland summary scores was about 17% of the total sample standard deviation (estimated slope, $D = -0.17$; $CI = -.029, -0.05$; $P = 0.004$), with less optimal mother-child interactions among the PCE dyads. In an effort to probe whether the observed PCE effect might be an artifact of or inseparable from the effects of other variables that might influence maternal-child interaction, the baseline model was elaborated to include covariates such as child age at testing; child sex; prenatal exposure to alcohol, tobacco, and marijuana; maternal age, education level, marital status, employment, gravidity; and number of prenatal care visits. Due to constraints on sample size, it was not possible to fit a model with all covariates entered simultaneously; instead, covariates were grouped into sets. The size of the PCE effect estimate with covariate control (Table 4, Models 2–5) did not differ appreciably from the Model 1 baseline estimate of -0.17 .

Table 5 summarizes estimates for the impact of PCE on maternal-child interaction in the context of past-year maternal cocaine use. This set of analyses evaluates the degree to which the estimated PCE effect is influenced by ongoing postnatal maternal cocaine use. Past-year maternal cocaine use was measured by positive maternal self-report of cocaine use during the year preceding either the 3- or 5-year study visit. The sample included 96 children with PCE but no evidence of past-year maternal cocaine use at either follow-up visit; 29 had PCE plus past-year maternal cocaine use before the 3-year study visit only; 17 had PCE plus past-year maternal cocaine use before the 5-year visit only; 23 had PCE plus past-year maternal cocaine use before both follow-up visits. There were 5 children with past-year maternal cocaine use but without PCE; these children were excluded since this subsample is too small for estimation purposes.

Using GLM/GEE, the Egeland summary score at each study visit was regressed on covariate terms for PCE, past-year cocaine use, and a product-term for PCE*past-year maternal cocaine use, allowing for paired contrasts of Egeland summary scores between the reference group of non-exposed maternal-child dyads (i.e., $n=193$ with neither prenatal nor past-year cocaine exposure) and those in two groups: i) PCE in the absence of past-year maternal cocaine use; and ii) PCE with past-year maternal cocaine use.

In Model 1, the mean Egeland summary score for children with both PCE and maternal past-year cocaine use is an estimated -0.27 units lower than the mean score for NCE children ($p<0.001$). The second estimate from Model 1, a contrast of scores for NCE children versus PCE children without past-year maternal cocaine use, indicates a smaller difference (-0.11) that is not statistically significant. As shown in Table 5 Models 2–8, the inclusion of a number of covariates measured at the 3- and 5-year follow-up visits produced no appreciable

variation in the Model 1 estimate of the cocaine-associated maternal-child interaction difference (estimates ranging from -0.18 to -0.27) with one exception. There was modest attenuation of the baseline estimate for dyads with both PCE and past-year maternal cocaine use when other maternal postnatal drug use was included (Model 3; $D = -0.18$; $CI = -0.36, 0.003$; $P = 0.054$). In Model 2, maternal psychological distress was related to poor overall maternal-child interaction. However, its inclusion did not attenuate the observed cocaine effect. Model 5 included terms for the number of caregiver changes, daycare attendance, and receipt of developmental services. Holding these variables constant, the estimate associated with both prenatal and postnatal maternal cocaine use was diminished but remained statistically significant ($D = -0.18$; $CI = -.35, -0.01$; $P = 0.042$).

Table 6 summarizes the means and standard deviations for each Egeland subscale at the 3 and 5-year visits. The final series of models utilized GLM/GEE multivariate profile analysis to examine the effect of PCE on the individual Egeland facets at the 5-year visit (data not shown in table); multivariate contrasts for the 14 Egeland subscales at age 3 were previously reported in Johnson et al.¹⁶ At age 5, the baseline model revealed that PCE was most strongly associated with the Egeland subscales of Maternal Intrusiveness ($D = 0.24$; $CI = .01, 0.46$; $P = 0.041$) and Boundary Dissolution ($D = 0.28$; $CI = .05, 0.50$; $P = 0.016$). Subsequent models included a number of covariates: child sex; child age at exam; prenatal exposures to alcohol, tobacco, marijuana; past-year maternal cocaine, alcohol, cigarette, and marijuana use; maternal education level, employment, and marital status at the 5-year follow-up; and daycare attendance and receipt of developmental services at age 5. With covariate control, PCE-associated estimates for Maternal Intrusiveness and Boundary Dissolution remained stable and statistically robust. Additionally, in this covariate-adjusted model, PCE was associated with Child Compliance ($D = -0.23$; $CI = -.47, -0.004$; $P = 0.046$), with PCE children exhibiting greater noncompliance during the maternal-interaction tasks.

DISCUSSION

The purpose of this study was to examine the impact of maternal cocaine use on mother-child interactions measured longitudinally during the preschool years. Findings suggest that mothers who used cocaine during pregnancy and their prenatally exposed children had less optimal quality of maternal-child interactions compared to mother-child dyads with no history of prenatal cocaine exposure. The estimated effects of PCE on the overall quality of maternal-child interactions at the age 3 and 5-year visits were similar in magnitude and were not significantly diminished with statistical adjustment for child sex, child's age at exam and covariates measured at the time of delivery. Study results also suggest prenatal cocaine effects on specific facets of mother-child interaction at age 5, with greater maternal intrusiveness, higher levels of boundary dissolution, as well as greater child noncompliance in PCE dyads compared to NCE dyads.

Maternal cocaine use during the year prior to the 3 and/or 5-year study visit also negatively impacted the overall quality of mother-child interaction. PCE dyads with past-year maternal cocaine use had significantly lower Egeland summary scores compared to children with neither PCE nor past-year maternal cocaine exposure. With past-year maternal cocaine use in the model, PCE's impact on maternal-child interaction was no longer statistically significant. This suggests the impact of maternal cocaine use on maternal-child interaction may be greatest when the mother uses cocaine during pregnancy and continues her drug use into the early childhood years. It is also possible the direct effect of PCE on maternal-child interaction was diminished due to a loss of statistical power related to the division of PCE children into two categories (those with and without past-year maternal cocaine use). These results remained stable with the addition of confounding variables into the model, with the

exception of past-year maternal alcohol, tobacco and marijuana use. Due to significant interdependence among the maternal past-year substance use variables, it may be difficult to statistically separate the unique effects of maternal cocaine use on maternal-child interaction.

Current results are in line with our prior published findings on maternal-child interaction at age 3 and provide additional evidence of enduring PCE-effects on maternal-child interaction through the preschool years.¹² We previously found PCE-associated differences in overall mother-child interaction during videotaped semi-structured free-play at age 3, with the greatest impairments noted in dyads where the mother reported past-year cocaine use. Additionally, as reported in Johnson et al.,¹² multivariate profile analysis of maternal-child interaction data at 3-years follow-up revealed higher levels of maternal intrusiveness and hostility, poorer quality of instruction, lower levels of maternal confidence, and reduced child persistence among PCE dyads compared to NCE dyads. In the current study, PCE-associated differences were noted on maternal intrusiveness, boundary dissolution and child compliance at age 5. Although the estimates for other subscales did not reach statistical significance, Egeland subscales such as maternal hostility showed a trend and likely contributed to the PCE-associated differences in the overall quality of maternal-child interaction measured by the Egeland total score. Differences in results between 3- and 5-year Egeland facets may be due in part to the unreliability of individual subscales to reflect developmental changes in mother-child interaction across the preschool period. Overall, findings from this study are consistent with other studies associating maternal cocaine use during pregnancy and early childhood with greater maternal hostility and insensitivity and less responsive and more intrusive interaction styles.^{1,4-6}

The current study offers numerous methodological advantages over previous studies including a large sample size, prospective enrollment at birth, a demographically similar comparison group, excellent cohort retention, and verification of prenatal drug exposure by bioassays. It is also one of the few longitudinal investigations examining maternal-child interaction at more than one time-point during the preschool period. The use of advanced multivariate longitudinal modeling techniques, (i.e. GLM/GEE) allowed for the estimation of the impact of PCE on maternal-child interaction while statistically adjusting for prenatal exposure to other drugs or potentially confounding influences. Additionally, mother-child interactions were assessed using standardized direct observational methods rather than through maternal self-report or agency reports of child abuse and neglect. Raters were blind to prenatal drug status and maternal reports of past-year drug and alcohol use were collected by interviewers who were not involved in the administration or evaluation of the mother-child interaction activities.

Important methodological characteristics and limitations of the MPCS have been summarized in prior publications.^{12,13,20} The current report relied on maternal self-report for the assessment of past-year maternal substance use. Although procedures were established to encourage valid reporting (i.e. the use of trained interviewers and the attainment of a federal certificate of confidentiality), poor maternal recall or the stigma associated with illicit drug use may have resulted in underreporting of maternal drug use. Also, the sample for this paper was restricted to children who remained with their biological mothers at the 3- and/or 5-year visits, potentially excluding children who might have been more heavily cocaine-exposed and as a result removed from the care of their mother. Such sampling procedures may have lead to an underestimation of PCE-associated effects on maternal-child interaction.

The current investigation further supports the link between maternal prenatal and postnatal cocaine use and quality of maternal-child interaction during the preschool years. Quality of

early parent-child interactions has been shown to impact child socio-emotional, developmental and academic, and behavioral outcomes. Medical and mental health professionals should be aware of the potential interactive impact of prenatal cocaine exposure and ongoing maternal substance use on maternal-child interaction. PCE has been associated with poorer state regulation and arousal modulation in infancy,²⁰ and with greater attention,²¹ language,²² and in some studies, behavioral problems during childhood,²³ which have the potential to influence mother-child interaction.^{2,6} Substance-using mothers who have comorbid psychopathology, high levels of stress, and ineffective parenting skills may have greater difficulties understanding and responding appropriately to infant cues, particularly in infants who may be poorly regulated.^{2,24}

Other associated parenting and environmental factors may also be important in explaining variability in mother-child interactions. Maternal cocaine use has been associated with higher rates of parental neglect and abuse, mental health issues, family instability and exposure to violence.²⁵ Consequently, interventions should not only target ongoing maternal substance use, but the individual and cumulative effects of environmental, social, and emotional factors associated with maternal substance use on maternal-child interactions. In a review of the literature, Suchman et al.,²⁶ examined interventions aimed at improving maternal-child interaction among mothers with a history of substance use and/or abuse and found that the most promising programs were comprehensive, intensive and addressed multiple aspects of the caregiving environment. In general, few interventions targeting maternal-child interactions among substance-using women and their children have been systematically evaluated; however, programs that include motivational engagement strategies and target maternal responsiveness have been shown to be successful in improving maternal behavior and the overall quality of the parent-child attachment relationship.^{26,27} While such research begins to identify specific components that can be incorporated into prevention and intervention efforts, ongoing research is needed to examine the underlying causes and long-term consequences of PCE-associated differences in maternal-child interactions, the impact of targeted interventions, and the application of this knowledge to other populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

PCE	prenatal cocaine exposure
PCS	Miami Prenatal Cocaine Study
GLM	general linear model
GEE	General estimating equations
NCE	noncocaine-exposed
CI	confidence intervals

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Table 1

Maternal and Infant Characteristics at Birth Enrollment (N = 366)

Maternal Characteristics	Non-Cocaine-Exposed (n=198)	Cocaine-Exposed (n=168)
Maternal age (years) **	23.7 (5.5)	28.8 (4.8)
Education (years)	11.2 (1.4)	11.3 (1.3)
Unemployed **	83.3% (165)	93.5% (157)
Never married	88.9% (176)	89.9% (151)
Prenatal care ≥ 4 visits *	84.3% (167)	74.4% (125)
Primigravida **	24.2% (48)	7.7% (13)
Infant Characteristics		
Birth weight (gm) **	3301 (488)	2991 (480)
Birth length (cm) **	50.8 (2.3)	49.1 (2.5)
Birth head circumference (cm) **	33.8 (1.4)	33.0 (1.6)
Gestational age (wks) *	39.7 (1.4)	39.4 (1.4)
Male (%)	51.5% (102)	49.4% (83)

Note: Maternal and infant characteristics are expressed as mean (standard deviation) or percentage (numerator n) where (%) is indicated.

*
 $p < 0.05$;

**
 $p < 0.01$

Table 2

Maternal Self-Reported Drug Use during Pregnancy (N = 366)

	Non-Cocaine-Exposed (n=198)		Cocaine-Exposed (n=168)	
	Median Dosage (Min, Max)	% (n) Reporting Use	Median Dosage (Min, Max)	% (n) Reporting Use
Alcohol (# drinks) ^b	54 (2, 1680)	28.8% (57)	74 (1, 3823)	64.9% (109)
Tobacco (# cigarettes) ^{a,b}	1008 (3, 5880)	15.7% (31)	2000 (2, 8820)	70.8% (119)
Marijuana (# joints) ^b	37 (1, 807)	12.1% (24)	26 (1, 798)	42.3% (71)
Cocaine/crack(# lines/rocks)			101 (1, 19320)	64.3% (108)

Note: Maternal substance use is expressed as median (min/max) due to skewed distributions. Median values were based only on mothers who reported drug use at birth within the subsample of 366 children; drug use composites were calculated as follows: (number of weeks used) × (usual number of days per week) × (usual dose per day).

^a $p < 0.05$, between-group comparison of median maternal drug use (columns 1 and 3).

^b $p < 0.01$, between-group comparison of percentage reporting drug use (columns 2 and 4; all p -values were < 0.01 for these comparisons).

Table 3

Maternal and Child Characteristics Assessed at 3 and 5 Years (N=366)

	Visits	Non-Cocaine-Exposed (n=198)	Cocaine-Exposed (n=168)
Maternal characteristics			
Education (years)	3 yr	11.3 ± 1.3	11.1 ± 1.4
	5 yr *	11.5 ± 1.3	11.1 ± 1.5
Unemployment	3 yr **	64%	81%
	5 yr *	60%	74%
Never married	3 yr	74%	72%
	5 yr	67%	71%
Maternal past-year cocaine use	3 yr **	1%	33%
	5 yr **	3%	31%
Maternal past-year marijuana use	3 yr **	11%	26%
	5 yr **	17%	35%
Maternal past-year alcohol use	3 yr	40%	46%
	5 yr	65%	69%
Maternal past-year tobacco use	3 yr **	16%	66%
	5 yr **	24%	67%
GSI	3 yr	55.7 ± 11.0	55.8 ± 11.8
	5 yr	55.1 ± 53.3	54.3 ± 52.2
Child characteristics			
Age at assessment (mo)	3 yr *	40.5 ± 3.6	39.7 ± 3.0
	5 yr	66.1 ± 2.5	65.7 ± 2.3
Caregiver changes	0–36 mo *	0.08 ± 0.33	0.19 ± 0.52
	37–60 mo *	0.01 ± 0.11	0.09 ± 0.44
Child cognitive status ^a	3 yr	82.4 ± 13.0	81.8 ± 10.7
	5 yr	81.7 ± 11.7	81.1 ± 10.7
Special developmental services	3 yr	1%	3%
	5 yr	11%	13%
Head Start/PreK	5 yr*	69%	56%
Blood lead ≥ 10µg/dL	3/5 yr*	8%	15%

^a McCarthy Scales of Children's Abilities (MSCA)²⁸ at age 3 and Wechsler Preschool and Primary Scale of Intelligence (WPPSI-R)²⁹ at age 5.

Table 4

GLM/GEE Models Estimating the Egeland Summary Score Difference Between Prenatally Cocaine-Exposed and Non-Cocaine-Exposed Children (n = 366)

	Estimated Difference ^a	95% C I	p-Value
Model 1			
Prenatal cocaine exposure (no other covariates)	−0.17	−0.29, −0.05	.004
Model 2			
Prenatal cocaine exposure, child sex, and test age	−0.16	−0.28, −0.04	.008
Model 3			
Subsumes Model 2, plus terms for level of prenatal exposure to alcohol, marijuana, and tobacco based on maternal self-report	−0.14	−0.26, −0.01	.035
Model 4			
Subsumes Model 2, plus terms for maternal age, years education, marital status, and employment	−0.13	−0.27, 0.0002	.050
Model 5			
Subsumes Model 2, plus terms for primigravida status and prenatal care visits	−0.17	−0.29, −0.04	.007

CI, confidence interval.

^aEstimated difference associated with prenatal cocaine exposure, controlling for birth covariates. Difference estimates expressed in SD units for the Egeland Summary Score

Table 5

Estimated Effects Under Several GLM/GEE Models of Maternal Prenatal and Postnatal Cocaine Use on the Egeland Summary Score at the 3 & 5-Year Follow-Up Visits

	Estimated Difference ^a	95% C I	p-Value
Model 1 (adjusted for child age and sex)			
Prenatal cocaine exposure with maternal past-year cocaine use	−0.27	−0.43, −0.11	.001
Prenatal cocaine exposure without maternal past-year cocaine use	−0.11	−0.24, 0.02	.090
Model 2 (adjusted for child age, child sex and maternal psychological symptoms (GSI score))			
Prenatal cocaine exposure with maternal past-year cocaine use	−0.26	−0.43, −0.10	.001
Prenatal cocaine exposure without maternal past-year cocaine	−0.12	−0.25, 0.01	.071
Model 3 (adjusted for child age, child sex, and maternal past-year alcohol, tobacco, marijuana use)			
Prenatal cocaine exposure with maternal past-year cocaine use	−0.18	−0.36, 0.003	.054
Prenatal cocaine exposure without maternal past-year cocaine	−0.05	−0.19, 0.09	.485
Model 4 (adjusted for child age, child sex, and maternal current education, employment, and marital status)			
Prenatal cocaine exposure with maternal past-year cocaine use	−0.21	−0.38, −0.05	.013
Prenatal cocaine exposure without maternal past-year cocaine	−0.10	−0.24, 0.04	.146
Model 5 (adjusted for child age, child sex, number of caregiver changes, daycare attendance, and special developmental services)			
Prenatal cocaine exposure with maternal past-year cocaine use	−0.18	−0.35, −0.01	.042
Prenatal cocaine exposure without maternal past-year cocaine	−0.09	−0.22, 0.05	.224
Model 6 (adjusted for child age, child sex, and head start/pre-kindergarten)			
Prenatal cocaine exposure with maternal past-year cocaine	−0.21	−0.39, −0.03	.019
Prenatal cocaine exposure without maternal past-year cocaine	−0.10	−0.23, 0.03	.133
Model 7 (adjusted for child age, child sex and child cognitive status ^b)			
Prenatal cocaine exposure with maternal past-year cocaine use	−0.25	−0.41, −0.09	.002
Prenatal cocaine exposure without maternal past-year cocaine	−0.10	−0.23, 0.02	.108
Model 8 (adjusted for adjusted for child age, child sex, and child lead exposure)			
Prenatal cocaine exposure with maternal past-year cocaine use	−0.26	−0.42, −0.09	.002
Prenatal cocaine exposure without maternal past-year cocaine	−0.10	−0.23, 0.03	.131

CI, confidence interval.

^aEstimated difference associated with prenatal cocaine exposure, controlling for child sex and test age and postnatal covariates. Difference estimates expressed in SD units for the Egeland Summary Score.

^bCognitive status was measure using the McCarthy Scale of Children's Abilities General Cognitive Index (GCI)²⁸ at age 3 and the Wechsler Scale of Preschool and Primary Intelligence-Revised (WPPSI-R)²⁹ at age 5.

Table 6

Egeland Subscale Scores in Cocaine-Exposed and Non-Cocaine-Exposed Dyads (N=366)

Egeland Subscales	Visits	NCE Mean $\pm$ SD	PCE Mean $\pm$ SD
Maternal Behavior			
Maternal Intrusiveness ^b	3 yr	2.52 $\pm$ 1.46	3.31 $\pm$ 1.66
	5 yr	1.95 $\pm$ 1.12	2.23 $\pm$ 1.19
Maternal Hostility ^b	3 yr	2.30 $\pm$ 1.54	3.00 $\pm$ 1.66
	5 yr	1.80 $\pm$ 1.28	2.04 $\pm$ 1.21
Quality of Instruction ^a	3 yr	3.73 $\pm$ 1.64	3.22 $\pm$ 1.49
	5 yr	4.67 $\pm$ 1.38	4.57 $\pm$ 1.42
Maternal Confidence ^a	3 yr	1.85 $\pm$ 0.77	1.63 $\pm$ 0.71
	5 yr	2.16 $\pm$ 0.75	2.19 $\pm$ 0.73
Maternal Support ^a	3 yr	3.85 $\pm$ 1.80	3.50 $\pm$ 1.55
	5 yr	4.67 $\pm$ 1.64	4.58 $\pm$ 1.51
Child Behavior			
Child Persistence ^a	3 yr	4.06 $\pm$ 1.35	3.71 $\pm$ 1.36
	5 yr	5.13 $\pm$ 1.25	5.05 $\pm$ 1.13
Child Enthusiasm ^a	3 yr	3.99 $\pm$ 1.44	3.73 $\pm$ 1.40
	5 yr	4.72 $\pm$ 1.42	4.73 $\pm$ 1.36
Child Negativity ^b	3 yr	2.59 $\pm$ 1.55	2.83 $\pm$ 1.56
	5 yr	1.80 $\pm$ 1.10	1.96 $\pm$ 1.26
Child Compliance ^a	3 yr	4.48 $\pm$ 1.48	4.30 $\pm$ 1.46
	5 yr	5.21 $\pm$ 1.34	4.95 $\pm$ 1.20
Child Experience of Session ^a	3 yr	4.12 $\pm$ 1.55	3.82 $\pm$ 1.44
	5 yr	4.89 $\pm$ 1.42	4.77 $\pm$ 1.35
Child Affect to Mother ^a	3 yr	4.05 $\pm$ 1.53	3.85 $\pm$ 1.43
	5 yr	4.80 $\pm$ 1.42	4.81 $\pm$ 1.23
Child Avoidance ^b	3 yr	3.24 $\pm$ 1.87	3.15 $\pm$ 1.83
	5 yr	2.23 $\pm$ 1.36	2.37 $\pm$ 1.35
Dyadic Interaction			
Quality of the Relationship ^a	3 yr	3.55 $\pm$ 1.63	3.31 $\pm$ 1.50
	5 yr	4.51 $\pm$ 1.49	4.46 $\pm$ 1.41
Boundary Dissolution ^b	3 yr	3.10 $\pm$ 1.48	3.17 $\pm$ 1.57
	5 yr	2.19 $\pm$ 1.32	2.56 $\pm$ 1.38

Note: All subscales are rated using a seven-point scale, except Maternal Confidence which is scored on a three-point scale.

^aLow scores reflect poor performance;

^bHigh scores reflect poor performance