Effects of Prenatal Cocaine Exposure and Postnatal Environment on Child Development

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ABSTRACT Studies on the long-term developmental effects of in utero cocaine exposure are few and the small number of studies published do not consider the postnatal environment. The present investigation was conducted to quantify the role that postnatal environment played compared to prenatal exposure. Four groups of 25 infants, each assessed at 12 months of age, were included in the study design: 1) noncocaine-exposed children residing with their biological parents in low socioeconomic environments, 2) cocaine-exposed children living with their biological parents in low socioeconomic environments, 3) noncocaine-exposed children adopted at birth in middle to upper-middle socioeconomic environments, and 4) cocaine-exposed children adopted at birth. Infants were assessed by the Uzgiris-Hunt Ordinal Scales of Infant Psychological Development, the Fagan Test of Infant Intelligence, and the Infant Monitoring Questionnaire. Height and head circumference were measured. Gender and ethnicity were controlled statistically. Significant differences were found in cognitive functioning, in fine motor development, and in physical growth between control and prenatally cocaine-exposed children. Adoption enhanced cognitive functioning and fine motor skills among infants not exposed to cocaine prenatally, but had no apparent effect on infants prenatally exposed to cocaine. Am. J. Hum. Biol. 12:417–428, 2000.

Several published studies and reports in the popular press suggest that in utero cocaine exposure is associated with atypical neurobehavioral development and prenatal growth retardation (Little, 1991; Little and Snell 1991a,b; Azuma and Chasnoff, 1993; Frank et al., 1993; Brooks-Gunn et al., 1994; Jacobson et al., 1996; Greene et al., 1998). Research indicates that cocaine remains an illegal drug frequently used by women of childbearing age (Schutter and Brinker, 1992; Scherling, 1994) and the incidence of cocaine usage may even be increasing. Data from a survey in which 36 hospitals across the country were contacted by phone and asked to estimate the percentage of drug-exposed newborns shows that approximately 11% of the women who delivered in these hospitals had used illegal drugs during pregnancy, including cocaine, marijuana, and heroin (Chasnoff, 1992). The U.S. General Accounting Office (GAO, 1990) and the President's National Drug Control Office stated that the number of cocaine-exposed children born each year was at least 100,000 (Lawton Hawley and Disney, 1990). One study revealed that 31% of the infants born in a Baltimore public hospital tested positive for cocaine in meconium (Nair et al., 1994). Osterloh and Lee (1989)

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reported a record high rate of 48% of women using cocaine during pregnancy in a San Francisco public hospital. Thus, if prenatal cocaine exposure is inducing permanent neurological damage, a large number of infants and children are at risk.

Alarming reports in the popular press in the late 80s and early 90s concerning "crack babies" and "coke kids" have subsided. However, questions about the impact of prenatal cocaine exposure on child development remain. Scientifically reliable information on the prognosis of cocaine-exposed children is needed.

The purpose of the present investigation was to assess infants prenatally exposed to cocaine who reside with their biological parents and those who were adopted and compare them with children who were not exposed to the drug but lived in similar environments.

MATERIALS AND METHODS

Subjects

More than 650 infants born at Parkland Memorial Hospital, a county hospital in Dallas, Texas, were identified and screened at birth for cocaine-exposure over a 5-year study period. Only children who tested positive for cocaine at birth and whose mothers declared cocaine their primary drug of choice were included in the study. An intense effort was made to exclude infants of mothers who used alcohol and other drugs. This was a difficult and sample-size limiting criterion and resulted in the exclusion of more than 350 infants from the study because of polydrug exposure. This was necessary because of the well-documented teratogenic effects of alcohol exposure (Little et al., 1989a, 1990a, 1995; Streissguth et al., 1992, 1993, 1996). Of the 300 children eligible to participate in the study, 150 cocaine-exposed children and 150 nondrug-exposed children functioning as a control group were included in the research project. Only children with a gestational age of 38–42 weeks were included. All children were evaluated at birth by a tester unaware of the drug-exposure status of the children.

At the time of the children's first birthday, the mothers of the cocaine-exposed children and of the control group children were contacted by mail and asked to return to the hospital for a 1-year evaluation of their infants. A large number of mothers and children could not be located for follow-up assessment. Each mother who could be reached and was available agreed to participate and the first 50 mothers and their children were included in the 12-month follow-up testing.

Parents of adopted children were informed by various private adoption agencies of the purpose of the study and were asked to participate. Most of the adopted children were born in public hospitals (Parkland Memorial Hospital in Dallas and John Peter Smith Hospital in Fort Worth), where they were screened at birth for cocaine exposure in the same way as the nonadopted children. Sample sizes of 25 subjects were large enough to detect clinically significant differences (>20%) between the groups. The following study groups were established:

BC = Living with birth parent, control group
BD = Living with birth parent, drug-exposed
AC = Adopted, control group
AD = Adopted, drug exposure.

Of the 100 children, 57 were Afro-American, 39 Caucasian and 4 Hispanic. Fifty-six male and 44 female children were enrolled in the study (Table 1). The average age of the children was 55.0 weeks. The average age of the birth mothers was 26.5 years and of the adoptive mothers 33.9 years. The majority of the birth mothers (75%) had been in high school for some years, while 19% had some college or trade school education. Most of the adoptive mothers (71%) had finished college or graduate school, 10% had some college or trade school education, and 10% had finished high school. The birth mothers who had delivered their children at Parkland Memorial Hospital were likely to be or had been on welfare or had low-wage jobs (Little et al., 1990b). They lived in rental housing (89%) and were mostly single (88%). Eighty-seven percent of the adoptive mothers owned their homes and all but one of the mothers were married. The majority of the adopted children were placed in their adoptive homes before they were 2 months old. As compensation for their participation in the study, mothers were offered free transportation to and from the hospital, $10.00 McDonald's gift certificates, and a written report of their child's developmental progress. The Institutional Review Board of

TABLE 1. Study design and demographic data of subjects

COCAINE EXPOSURE		ADOPTED: NO	ADOPTED: YES
		Group BC	Group AC
	N	25	25
	Gender:		
	Male	11	14
	Female	14	11
	Ethnicity:		
	Caucasian	4	23
	African American	19	2
NO	Hispanic	2	—
	Child's age (weeks)	54.5	55.2
	Mother's age (years)	24.2	35.6
	Mother's educational level	Some high school	College
	Mother's income	Below FPL[a]	Above FPL[a]
	Residential status	Rent	Own
	Marital status	Single	Married
		Group BD	Group AD
	N	25	25
	Gender:		
	Male	14	17
	Female	11	8
	Ethnicity:		
	Caucasian	3	9
	African American	21	15
YES	Hispanic	1	1
	Child's age (weeks)	54.8	55.6
	Mother's age (years)	28.8	32.2
	Mother's educational level	Some high school	College
	Mother's income	Below FPL[a]	Above FPL[a]
	Residential status	Rent	Own
	Marital status	Single	Married

[a]95% of women delivering at Parkland Memorial Hospital do not pay for their services, which means that they live below the Federal Poverty Line (FPL). They are likely to be or have been welfare recipients.

the University of Texas Southwestern Medical Center approved the study.

Procedure

At the hospital mothers and children were greeted by a female research assistant and made comfortable to create a relaxed atmosphere. Mothers were informed of the procedures during the visit and requested to complete a questionnaire regarding the social and physical environment in which their children were living. After mothers gave informed consent, children were evaluated with three scales of the Uzgiris-Hunt Ordinal Scales of Infant Psychological Development (UHOS) and the Fagan Test of Infant Intelligence (FTII). The scales of the UHOS assess in ordinal and sequential fashion the infant's abilities and competence in several aspects of cognitive development. The following three scales were used in this study: 1) Construction of Object Relations in Space (Spatial Relations), 2) Relationship between Means and Ends (Means-End), and 3) Permanence of Objects (Object Permanence). The FTII was developed as a screening device for the early detection of delayed cognitive development of at-risk infants and children. The test is based on the infant's developing ability to perceive, retain, and recognize visual information. The child was then assessed with the Gross and Fine Motor Development Scales of the Infant Monitoring Questionnaire (IMQ). After the assessments the child's physical measurements were taken (height and head circumference). Developmental testing and motor and behavioral evaluations were done by an evaluator (TVB) who was blind to the drug-exposure status of the children. Information on reliability, ordinality, and stability of the UHOS is published (Uzgiris and Hunt, 1975; Dunst, 1980; Anastasi, 1982; Gorrell, 1985). Sensitivity, specificity, validity, and reliability of the FTII are also reported (Fagan and Singer, 1983; Fagan and Montie, 1986; Fagan et al., 1986; Fagan and Detterman, 1992; Montie et al., 1987) as are reliability and test-retest agreement of the IMQ (Bricker et al., 1988, Bricker and Squires, 1989; Squires et al., 1990).

The questionnaire completed by the birth or adoptive mother or the primary caregiver was structured to acquire information on maternal and paternal background, the parent(s) relationship with the child, the physical and social environment in which the child was living, and parental perception of the child's developmental status. Physical measurements were taken according to hospital protocol. Data were analyzed using SAS Software (SAS Institute, Cary, NC) release 6.06 with analysis of variance and covariance in the general linear models procedure.

RESULTS

Analysis of the effects of maternal cocaine use on child on cognitive, motor, and physical development of the child was accomplished in three parts: 1) effects of prenatal cocaine exposure on the child's development (cocaine exposure vs. nondrug exposure); 2) effects of adoption (enhanced environment) on the cognitive development of the child vs. living with birth parent(s); 3) interaction of prenatal cocaine exposure and postnatal environment on the development of the child.

Effects of prenatal cocaine exposure on the child's development

Significant differences due to the effect of cocaine on Spatial Relations ($P < 0.0001$), Means-End ($P < 0.0001$), and Object Permanence ($P < 0.04$) were found (Table 2). The two groups of cocaine-exposed infants (groups BD and AD) scored significantly lower on the three tests (Table 3). Results indicate a lower cognitive developmental age for BD and AD infants, regardless of their environment. No significant differences were found for the Fagan scores or for Gross Motor skills between the cocaine-exposed children and nondrug-exposed children, regardless of whether they were adopted or not. However, children from groups BD and AD demonstrated significant ($P < 0.0003$) deficits in Fine Motor development at 12 months of age on the IMQ compared to control infants (Table 2).

Cocaine-exposed infants were physically growth retarded compared to control infants, regardless of environment. Head circumference, an approximate indicator of brain growth, was significantly ($P < 0.0001$) smaller among infants who sustained prenatal cocaine exposure. Average measurements for children from groups BC and AC were 47.5 cm and children from groups BD and AD 46.2 cm (Table 3). Also, the difference in height between the group of cocaine-exposed children and the group of nondrug-exposed children was significant ($P < 0.002$). Those exposed to the drug were shorter, regardless of postnatal environment.

Effects of adoption vs. living with birth parent(s)

Spatial Relations and Means-End scores were significantly ($P < 0.04$ and $P < 0.005$, respectively) higher among adopted infants (groups AC and AD) compared to infants living with their biological parent(s) (groups BC and BD) (Table 2). Scores on Object Permanence and on the Fagan test were not significantly different between the adopted children and children living with their biological parent(s). Adoption had a significant effect on Fine Motor development ($P < 0.003$); adopted children performed better on tasks that required fine motor coordination than nonadopted children.

Interaction of prenatal cocaine exposure and postnatal environment on the development of the child

No significant differences were found in any measures of cognitive development (Spatial Relations, Means-End, Object Permanence, and the Fagan scores), motor development (Gross or Fine Motor skills), or physical growth (head circumference and height) due to the interaction of prenatal cocaine exposure and postnatal environment (Table 2).

t-tests were also conducted to examine differences among the four groups of subjects (Table 2). Effects of drug exposure on cognitive development, motor development, and physical growth of children from group BD and children from group AC were analyzed. Significant differences were found in Spatial Relations ($P < 0.0002$), Means-End ($P < 0.0001$), and Object Permanence ($P < 0.02$) on cognitive development tasks and on Fine Motor ($P < 0.0001$) in motor development measures with infants from group AC

*TABLE 2. ANOVA and ANCOVA and means and standard deviations of the differences between nondrug-exposed and cocaine-exposed infants, living with their birth mother and those who were adopted (N = 100)**

	Main effects				Interaction		Covariates							Group differences[a]					
	Cocaine		Adoption		CXA		Gender		Ethnicity		Total			AC vs. BD	BC vs. AD	BC vs. BD	AC vs. AD	BC vs. AC	BD vs. AD
Variables:	F	*P*	F	*P*	F	*P*	F	*P*	F	*P*	F	*P*	R2						
Spatial relations	15.87	0.0001	4.35	0.04	1.04	NS	5.50	0.02	1.51	NS	5.38	0.0002	0.22	0.0002	NS	NS	0.001	NS	NS
Means-end	18.36	0.0001	8.16	0.005	0.31	NS	7.45	0.01	0.09	NS	7.84	0.0001	0.29	0.0001	NS	0.006	0.001	0.02	NS
Object permanence	4.39	0.04	2.00	NS	1.41	NS	3.45	NS	1.56	NS	3.62	0.005	0.17	0.02	NS	0.02	NS	NS	NS
Fagan score	3.56	NS	0.49	NS	0.40	NS	0.10	NS	0.37	NS	1.47	NS	0.07	NS	NS	NS	NS	NS	NS
Gross motor	1.16	NS	1.08	NS	0.06	NS	0.64	NS	0.00	NS	0.73	NS	0.04	NS	NS	NS	NS	NS	NS
Fine motor	13.81	0.0003	9.29	0.003	0.61	NS	1.52	NS	0.06	NS	6.61	0.0001	0.26	0.0001	NS	NS	0.003	0.01	NS
Head circumference (cm)	20.17	0.0001	0.03	NS	1.33	NS	5.35	0.02	0.06	NS	5.18	0.0003	0.23	0.007	0.001	0.0001	0.02	NS	NS
Height (cm)	10.04	0.002	0.25	NS	0.00	NS	0.29	NS	0.52	NS	2.05	NS	0.11	0.02	NS	0.02	NS	NS	NS

**T*-tests, alpha level adjusted to 0.025 with the modified Bonferonni test for planned comparison.
[a]Group BC = nondrug-exposed children, living with their birth parent; Group AC = nondrug-exposed children, adopted; Group BD = cocaine-exposed children, living with their birth parent; Group AD = cocaine-exposed children, adopted. NS = not significant.

TABLE 3. Means and standard deviations (N = 100)

	No drug exposure				Cocaine exposure			
	BC Birth parent		AC Adopted		BC Birth parent		AC Adopted	
Groups:	X	SD	X	SD	X	SD	X	SD
Spatial relations (months)	13.1	1.7	14.0	1.4	11.6	2.0	12.0	3.2
Means-end (months)	11.9	0.8	12.2	1.3	10.7	1.3	11.2	0.7
Object permanence (months)	13.1	2.5	13.8	2.3	11.3	2.5	12.8	2.3
Fagan score	61.2	6.5	62.4	7.0	57.4	7.1	59.7	7.5
Gross motor	6.5	1.0	6.7	0.5	6.3	1.1	6.4	0.8
Fine motor	4.9	0.8	5.6	0.4	4.3	1.0	4.8	1.0
Head circumference (cm)	47.7	1.8	47.3	1.3	46.0	1.3	46.4	1.3
Height (cm)	76.9	3.5	76.9	3.9	74.4	3.4	74.8	3.4

performing better in each domain than children from group BD. Physical growth was significantly different between AC and BD children in head circumference ($P < 0.007$) and height ($P < 0.02$), with AC children having a larger head and being taller than BD children.

Analysis of scores and outcome measures of children from group BC and children from group BD, both living with their birth parent(s) in low socioeconomic environments, indicated that the BC children performed better on cognitive measures of Means-End ($P < 0.006$) and Object Permanence ($P < 0.02$) than the BD children. They also had larger mean head circumference ($P < 0.0001$) and they were taller ($P < 0.02$). However, socioeconomic background differences were present due to drug-use in the homes of the children in group BD. Similar differences between scores in cognitive and motor development tests and in measurements of physical growth were found between children from group AC and group AD (Spatial Relations $P < 0.001$, and Means-End $P < 0.001$, Fine Motor development $P < 0.003$, head circumference $P < 0.02$). The socioeconomic backgrounds of these children (AC and AD) were comparable. Findings in the present study indicate a persistent negative impact of prenatal cocaine exposure on infant development.

Comparing evaluations of children from group BC with those of children from group AC differences were found in cognition (Means-End $P < 0.02$) and in Fine Motor skills ($P < 0.01$), emphasizing the influence of a better and more stimulating environment on child development. Comparing the scores and measures of children in group BD and those from children from group AD, no such differences were found. Results and scores did not significantly improve in children exposed to cocaine in utero living in enhanced postnatal conditions. No significant differences were detected between the two groups of children (groups BD and AD) in any area of development.

Analysis of covariance was conducted to examine the contributions of gender and ethnicity to the outcome of the analysis of variance (Table 2). Gender had a significant impact on cognitive performance (Spatial Relations $P < 0.02$ and Means-End $P < 0.01$), and on head circumference ($P < 0.02$). Females attained higher scores than males on cognitive tasks, but males had a larger head circumference than females. Ethnicity did not significantly influence the scores of cognitive and motor development tests or measures of physical growth.

DISCUSSION

The long-term effects of prenatal cocaine exposure on infant cognitive, motor, and physical development were investigated in this study while controlling for postnatal environment. The findings of this study are covered under three broad headings: 1) the effects of prenatal cocaine exposure on infant development, 2) the effects of the postnatal environment, and 3) the effects of the interaction between prenatal cocaine exposure and postnatal environment on the infant's neurobehavioral and physical development.

Effects of prenatal cocaine exposure

Cognitive development. Results of the present study showed significant differences in cognitive development scores between prenatally cocaine-exposed children and control children. Three areas of cognitive development investigated in the present study were significantly lower among children from groups BD and AD compared to children from groups BC and AC: 1) Spatial Relations, 2) Means-End, and 3) Object Permanence. These results indicate a higher level of cognitive development among noncocaine-exposed infants. Cognitive deficits were also detected in children born to cocaine-using mothers by Jacobson et al. (1996) and Richardson (1998), in contrast to other studies that reported no differences in cognitive development (Chasnoff et al., 1986; Griffith, 1992; Schutter and Brinker, 1992; Hurt et al., 1995; Franck, 1996). No differences were found between the two groups on the scores of the FTII.

No significant differences were found between groups of cocaine/polydrug-exposed and nondrug-exposed children who were evaluated at 6, 12, 18, and 24 months on cognitive development (Chasnoff et al., 1986, 1992). In addition, no significant differences were found in the overall scores between the cocaine/polydrug-exposed children and nondrug-exposed children on the Stanford-Binet Intelligence Scale (4th ed.) by Griffith et al. (1994), who reported on the same groups of children at 3 years of age. However, significantly lower scores on verbal reasoning were achieved by the cocaine/polydrug group.

Previous reports included only children of mothers who had received a comprehensive program of health care and prenatal treatment for substance abuse. Families received intensive intervention, including parenting skills education, home visits, and medical care. Children in these studies are not representative of typical cocaine-exposed children. Children in the present study were born to mothers who received no enhanced services or interventions. This implies that intervention/prevention services to pregnant drug abusers may ameliorate the negative effects found in the present study.

In addition, the FTII, Bayley Scales, McCarthy Scales of Children's Abilities, and the Stanford-Binet are highly structured, and not designed to detect subtle differences in cognitive development (Howard et al., 1989). The UHOS scales are less structured and permit impulsive and spontaneous behavior. Cocaine-exposed children score within the average range on structured cognitive tests, but exhibit deficits and delays in unstructured situations, such as free play (Howard et al., 1989; Hurt et al., 1995; Franck, 1996). Such activities require self-regulation, self-organization, self-initiation, and follow-through.

Some children react to stimulation by becoming lethargic and withdrawn, other infants may respond to overstimulation with extreme activity, high distractibility, and aggression (Lester et al., 1991; Griffith, 1992). The level of stimulation of the FTII for the child is low. This may explain the lack of significant differences between cocaine-exposed children and control children. Children who react to stimulation by becoming passive usually score well on the FTII. Children who refuse to sit quietly, move around constantly, kick the screen, and attempt to remove the pictures typically score poorly on the FTII. Therefore, it is not clear whether differences between groups of children are the result of cognitive delay or behavioral deficits (Struthers and Hansen, 1992).

Motor development. In the present study, prenatal cocaine-exposure had a significant effect on one aspect of motor development, fine motor skills, but no effect on gross motor development. Findings from other studies are not consistent.

In utero cocaine exposure is associated with seizures, irritability, impairment in state organization (Chasnoff et al., 1986), hypertonicity and tremulousness (Richardson et al., 1996), inability to perform in orientation (Phillips et al., 1996), and impaired habituation in the newborn (Howard 1989; Martin et al., 1996). These symptoms are considered to be the result of neurological damage. Deficits in motor development observed in the present study and by Schneider et al. (1989) may be the result of central nervous system damage and may be permanent. Chasnoff et al. (1992) found no differences between cocaine-polydrug-exposed children and control children at 12 months of age in mean psychomotor scores on the Bayley Scales, but a significant difference was detected in motor scores at 6 months. Significantly more children in the cocaine-exposed group scored one standard deviation below the normative mean score of 100 on the Bayley Scales compared to controls (Chasnoff et al., 1992). This finding was confirmed by Mayes and Cichetti (1995), who found that cocaine-exposed infants showed significantly lower psychomotor performance scores on the Bayley Scales of Infant Development than nondrug-exposed infants. Van Baar (1990) found that scores on the Bayley Scales of infants at 6, 12, 18, 24, and 30 months of age exposed to drugs in utero did not differ from the scores of control children at any age.

Physical growth. Investigations of cocaine exposure on fetal physical development have consistently reported intrauterine growth retardation; specifically, retardation in length (height), weight, and head circumference (Cherukuri et al., 1988; Dow-Edwards, 1991; Lester et al., 1991; Little et al., 1989b, 1991; Little and Snell, 1991b; Chasnoff, 1992; Coles et al., 1992; Schutter and Brinker, 1992; Mayes and Cichetti, 1995; Greene et al., 1998). Unfortunately, most studies reported birth status and little data are available regarding postnatal growth of children exposed prenatally to cocaine.

In the present study, significant differences in height and head circumference measurements were found between children from groups BD and AD on their first birthday and children from groups BC and AC of the same age. Cocaine-exposed infants had significantly smaller heads and shorter stature than nondrug-exposed infants.

In the only other study that evaluated the effect of in utero cocaine exposure on physical size and head circumference of children at 12 months of age (Chasnoff et al., 1992), significant decrease in head size was found among children with prenatal cocaine exposure compared with nondrug-exposed children. No differences in length were found. At birth, length and head size were significantly different between the two groups, with the drug-exposed children having diminished size. Importantly, cocaine-exposed children do not exhibit catch-up growth in head circumference during the first year of life and this may have important implications for later cognitive development.

Controlling for an extensive set of confounding variables (including parental size) investigators found a significant positive correlation between head circumference and scores on standardized intelligence tests among more than 200 children followed prospectively from birth to age 3 (Ernhart and Marler, 1987). Small head circumference at birth was found to be a significant predictor of poor cognitive developmental outcome in other investigations (Gross et al., 1983; Hack et al., 1991). Absence of catch-up growth in head circumference during the first year may indicate permanent damage, but whether the effects of intrauterine growth retardation will resolve during early childhood is unknown.

Effects of postnatal environment (adoption) on cognitive development

A primary tool to evaluate postnatal vs. prenatal environmental influences is the study of adopted children. Physical and social environments are known to significantly affect child growth, maturation, and development (Werner et al., 1971; Sameroff, 1975; Hunt, 1976; Wachs and Gruen, 1982; Sameroff and Seifer, 1983; Parker et al., 1988; Kronstadt, 1991; Zuckerman, 1991). Children born in low socioeconomic backgrounds and adopted into middle or upper-middle class families generally perform better on intellectual and achievement tests than children living with their biological parent(s) in lower class environments (Hu, 1987; Capron and Duyme, 1991). Infants already at risk for developmental delays due to prenatal cocaine-exposure may be at increased risk for delay because of adverse postnatal environment (low socioeconomic status of the mother, inner-city life, maternal drug use, poor parenting practices).

Results of the cognitive assessments of the group of adopted children (AD and AC) compared to the results of similar tests of the group of nonadopted children (BD and BC) showed that adoption positively affected two areas of cognitive development: Spatial Relations and Means-End. Adopted children had significantly better performance on cognitive tests than nonadopted children. Children from groups BC and BD scored significantly below their age level. Similar findings were reported by Hu (1987) in an analysis of infant cognitive performance of adopted and nonadopted children, with the caregiving environment accounting for the majority of differences in cognitive performance between the two groups at 12 months of age. Capron and Duyme (1991) investigated the influence of adoptive and biological parents' socioeconomic status on the IQ of 38 adopted children and concluded that the postnatal environment of children affected their scores on the Full, Verbal, and Performance Scales of the Wechsler Intelligence Scale for Children–Revised.

In contrast, a large genetic influence on intellectual and cognitive development was found in children in the Colorado Adoption

Project who were assessed on a battery of tests of cognitive abilities and who were evaluated at regular intervals over 7 years (Plomin and DeFries, 1985). An affiliated study by DeFries et al. (1987) found significant correlations between IQs of birth mothers and IQs of their offspring who were adopted. Coon et al. (1990) hypothesized that it was possible to detect direct effects of the environment if the environment in which the child was placed after adoption differed widely from the environment of the biological mother of the child.

In the present study, differences between postnatal environmental conditions of the children living with their biological parent(s) and those of the adopted children are significant. Children in this study living with their birth parent(s) (groups BC and BD) came from a predominantly indigent population, with mothers who are single, have a low level of education, and a history of sporadic minimum-wage jobs (Little et al., 1990b). In contrast, adoptive parents in this study were college-educated, employed, married, and able to offer their children (groups AC and AD) a stable home environment.

Children in both drug-exposed groups (BD and AD) attained scores for the Object Permanence Test and for the Fagan Test not significantly different from nondrug-exposed children (BC and AC). Rose et al. (1988, 1991) found that some cognitive processes appear not to be affected by environmental variables such as socioeconomic status, maternal education, etc., and that specific cognitive processes develop independently. These investigators studied information processing skills of high-risk, preterm infants and a control group of full-term infants from low socioeconomic backgrounds at 1 year of age on object permanence, visual recognition memory, and several other cognitive abilities. Among children evaluated at regular intervals during childhood to 5 years of age, cognitive abilities (object permanence, visual recognition memory) functioned independently and predicted later intellectual functioning independently of one another. Bornstein (1989) found no correlation between the number of years mothers attended school and several measures of infant habituation performance or recovery to novelty, confirming findings of the present study. Other investigators also reported no association between measures of infant information processing and some socioeconomic variables (Rose et al., 1991; Fagan and Singer, 1983; Duyme, 1988; Escalona, 1984). Certain aspects of cognitive functioning appear not to benefit from an enriched, more stimulating environment, while others do. In the present study, adopted children, regardless of cocaine exposure, performed better and at a higher developmental level in Spatial Relations and Means-End than nonadopted children.

Effects of the interaction of prenatal cocaine exposure and the postnatal environment: Cognitive development, motor development, and physical growth

Several reviews commenting on studies on the effects of prenatal cocaine exposure on child development have suggested that negative outcomes of assessments of cocaine-exposed children were due to the poor quality of the postnatal environment in which the children were living (Hutchings, 1993; Scherling, 1994). The present study considered the postnatal environment by comparing prenatally cocaine-exposed children from similar socioeconomic environments. Comparison of children from group AC with children from group AD showed that prenatally cocaine-exposed children scored below the level of the nondrug-exposed children on measures of cognitive development, fine motor development, and physical growth (head circumference). In this comparison, the SES of the children was similar. Thus, prenatal cocaine-exposure is the obvious proximate cause of the lower scores and the reduced physical growth of prenatally drug-exposed children.

In addition, assessments of children from group BC and those of children from group AC indicated that the improved living circumstances of the adopted children resulted in better performance. The enhanced living circumstances also improved the performance of the children from group AD when compared with the results of the children from group BC. The only difference found between the two groups was in head circumference. This finding was confirmed by the results of the Toronto Adoption Study in which the assessments of adopted, cocaine-exposed children (group AD) were compared to the performance of nondrug-exposed children, living with their birth mother (group BC) (Nulman et al., 1994). No differences were found between the two groups on the Bayley Scales but a significant difference in head size was observed. After controlling for the postnatal environment, the same researchers (Koren et al., 1998) reported in a recent publication that clinically significant language delay and a trend toward lower IQs were noted among cocaine-exposed children (group AD) as measured with the Reynell Language Test and the McCarthy Scales.

Unfortunately, the same conclusion could not be drawn from a comparison of the scores between the children from group BD and the children from group AD. No differences were found between BD and AD groups on any of the measures used in this study, indicating that the enhanced postnatal environment did not ameliorate impairment caused by prenatal cocaine exposure in cognitive and motor development, or head circumference and stature in children at 12 months of age.

In conclusion, maternal cocaine use during pregnancy accounted for significant decrements in development in children at 12 months of age. Negative effects of in utero cocaine exposure were observed in cognitive development, fine motor development, and physical growth. An enriched postnatal environment did not ameliorate these effects.

This study has limitations of small sample size, lack of matching on gender and ethnicity, possible maternal polydrug use, and infant age. The sample size of 100 subjects, divided over four groups, can be considered small, but is statistically significant when 20% differences in neurobehavioral and physical development are the detectable target.

Delays and impairments in the development of 12-month-old, cocaine-exposed children may have implications for long-term development. Results of prior studies of children prenatally exposed to cocaine (and other drugs) suggest that prevention/intervention services for pregnant substance abusers during gestation may have a significant and positive effect on child development (Hughes et al., 1995; Chasnoff et al., 1997). Longitudinal studies with large groups of subjects (adopted and living with their birth parent(s), drug-exposed and non-drug-exposed) are necessary for a comprehensive assessment of long-term development. These studies are established and under way.

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