COLES. C.D, K.A. BARD, K.A. PLATZMAN, AND M.E. LYNCH. Attentional response at 8 weeks in prenatally drug-exposed and preterm infants. NEUROTOXICOL TERATOL. To evaluate the effect of prenatal/polydrug exposure on infant attention, 105 8-week-old, African-American infants were presented a series of stimuli and heart rate (HR) recorded. Infants were identified postnatally based on mothers’ substance use. Four groups were tested: 1) preterm drug-exposed infants (n=24); 2) full term, drug-exposed (n=32); 3) preterm nonexposed (n=22); 4) full term, nonexposed (n=26). Preterm infants’ ages were corrected. Infants’ baseline HRs were recorded and then stimuli presented in the following order: auditory (rattle), visual (red ring) and social (examiner’s face and voice). There were no HR differences at baseline or in auditory or visual conditions. However, significant differences (F(2,103)=6.54, p<.01) were seen in response to social stimuli. Drug-exposed infants showed an acceleratory HR indicating distress or arousal and control infants showed an deceleratory response indicating focused attention. Hierarchical regression indicated cocaine, but not other drug, use (R²=.034, p<.05) and instability in parenting (R²=.137, p<.001) accounted for the observed differences.

Key Words: Cocaine in Pregnancy; Infant Attention; Heart Rate (HR), Quality of Caregiving

Concerns about prenatal cocaine and polydrug exposure have led to examination of many domains of infant outcome, including physical growth, neurodevelopmental status, and emotional/social functioning. At the present time, the most consistent findings indicate that prenatally-exposed children may be at higher risk for significant problems in arousal/attention (26,27,32), behavioral regulation (3,8,28) particularly an increased reactivity (21), and social/emotional functioning (2,7,9,13) especially as children move into later childhood (4). In infancy, prenatal cocaine exposure appears to influence social responsivity, speed of visual processing, and an interaction between arousal levels and learning. Karmel, Gardner and their colleagues have identified cocaine-related differences in attention and arousal modulation in newborns which persist through four months of age (27,28) and Mayes, Bornstein, Chawarska, and Granger (32) reported that cocaine exposure affected three-month-olds ability to complete
Attentional Response at 8 Weeks in Prenatally Drug

Although arousal and attention during early infancy are not completely analogous to these constructs in older children and adults, the achievement of self-regulation and the ability to focus attention and process social and other information are important precursors to normal development and problems in these areas may have implications for later functioning. Managing arousal in order to focus attention on stimuli and making appropriate responses are among the first cognitive and social skills acquired by the infant and probably form the basis of much later development. If there are reliable deficits observed in cocaine- and polydrug-exposed infants, it is important to establish their extent and etiology. However, in interpreting these findings, it is necessary to consider other factors that may contribute to effects or interact with the direct consequences of prenatal exposure. In addition to the possible acute effects in the neonatal period of the drugs being studied, it has often been observed that drug-exposed pregnancies place both mother and infant at higher medical risk, including the potential for preterm birth and its associated complications (30). While some studies (12) have found few negative effects of the interaction of prematurity and cocaine/polydrug exposure, others have identified such effects. For instance, Scafidi, Field, Wheeden, Schangber, et al. (39) reported that cocaine-exposed, preterm neonates responded to stress associated with attention maintenance less effectively than other preterms and were less able to regulate behavior during neurobehavioral examinations. A second area of concern for children born to women using drugs and alcohol in pregnancy is the potential effect of nonoptimal caregiving and these effects have not, as yet, been well studied although it is clear that such environments are high risk (7,13,43).

The current study focuses on attentional response at 8-weeks of age when the acute pharmacological effects of prenatal exposure are no longer present. We hypothesized that prenatal exposure to cocaine and other drugs might affect infant response to stimuli and that different stimuli might produce different responses. Similarly, we hypothesized that preterm birth which has been found by some authors to affect visual information processing in nonexposed infants (10) might be associated with differential response to visual and other stimuli in drug-exposed preterms. It was also possible that these responses might be additive or interactive so that preterm, drug-exposed infants might be predicted to show the most aberrant responses.

Eight weeks was chosen as a first point in development when infants are become more sociable (44), can self regulate (19,38) and can demonstrate focused attention with some reliability. For this study, from the several ways of measuring infant attention, HR was selected as being a well documented method which could be collected reliably at 8-weeks when infants often have difficulty completing other paradigms (e.g., 32). At this age, a majority of infants, under the right conditions, show a deceleratory heart rate (HR) response that is characteristic of focused attention (42). This response, which is defined by a decrease in HR with the onset of stimulus presentation and with a sustained focusing of attention, is contrasted with an acceleratory response characterized by an increase in HR which may be sustained for a period of time and is considered to be indicative of distress or increased arousal (41). The deceleratory response is a well-established phenomenon as are the parameters associated with it (14,36,37,41) and that it is present in early infancy has been demonstrated despite...
suggestions that an acceleratory response is characteristic of attention in the first few months of life (24). Deceleratory response is associated with information processing and occurs with the presentation of novel information (41,42). This response is probably composed of two phases (36), an orienting phase which occurs with the first presentation of the stimulus and lasts a few seconds, and a sustained attention phase which may last as long as the stimulus is providing novel information. In young infants, this may be 6 to 15 seconds or longer if the stimulus is maintained. A number of subject and stimulus conditions have been found to influence whether or not a deceleratory response occurs, including infant state, stimulus type and infants’ previous exposure to the stimulus (42).

Since cocaine-exposed infants have been found to show attentional alterations (25,32), the pattern of HR in response to a range of stimuli at this age might suggest the nature of such deficits. The auditory and visual system develop at different rates with the auditory system maturing before birth and the visual system achieving acuity much later, during the first year (1,10,29,31). We were also interested in the effect of postnatal caregiving on attentional response, especially response to social stimuli, which is particularly salient to infants of this age (8,34). Beeghly and Tronick (8) have demonstrated that the caregiving environment acts to facilitate the infant’s ability to self-regulate through the development of face-to-face communication, joint attention and mutual regulation. Although 8-week-old infants are relatively inexperienced, they have had a short lifetime of exposure to a caregiver and inadequate caregiving might have an effect on infants’ response to a social approach.

Specifically, our hypotheses were that: 1) drug-exposed infants would show alterations in HR responses relative to non-exposed controls when presented with a series of stimuli; 2) preterm infants would respond to stimuli with increased HR in comparison to full-term infants; 3) preterm, drug-exposed infants would respond to stimuli with the greatest HR changes; 4) responses to inanimate and social stimuli would differentiate the drug-exposed infants from the control infants and different stimuli would produce different patterns of effects.

Method

Subjects

Included in this study were 105 infants who completed an attentional protocol at 8- weeks conceptional age. They were a subset of a larger group of 148 who were tested at this age as part of a longitudinal study of the developmental effects of prenatal cocaine and polydrug exposure during pregnancy, and did not differ significantly from the larger group as a function of maternal drug use, term status or the other characteristics in Tables 1 and 2. Infants were selected in the postnatal period based on their mothers’ use of cocaine and other drugs during pregnancy and their gestational age at birth. Four groups of babies were identified: fullterm, drug-exposed and nonexposed, and preterm, drug-exposed and nonexposed. Fullterm was defined as having a Ballard (5) score of greater than or equal to 37 weeks and preterm as having a Ballard score of greater than 28 weeks and less than 37 weeks gestational age.
Recruitment of subjects was carried out at Grady Memorial Hospital, a large urban hospital affiliated with Emory University School of Medicine, which serves a predominantly African-American, low-income population. Recruiters reviewed obstetrical and pediatric intake records daily to identify mother/infant dyads who met study criteria. The purpose of these criteria was to provide a sample free of major social and medical confounds which might obscure effects of prenatal drug exposure. Selection criteria included: maternal age ≥19, English speaking, free of major medical conditions (e.g., HIV infection, active syphilis, diabetes, psychiatric disorders requiring medication, tuberculosis). Mothers were not included who used Antabuse, seizure medications, Warfarin, insulin, benzodiazepines, antipsychotic drugs or other drugs with teratogenic properties, as well as illicit recreational drugs (e.g., opiates) other than cocaine and marijuana. Infants were singletons or first born of twins and either healthy fullterms or preterms without major medical complications. Infants were not included if they: received oxygen for more than 28 days, developed major infections (TORCH, meningitis) had seizures, IVH (Grades III or IV), or periventricular leukomalasias, were diagnosed with genetic disorders or major malformations, were HIV positive or needed major surgery (such as for patent ductus arteriosus or necrotising enterocolitis) or showed other problems which might affect development independently.

For the 8-week follow-up, preterm infants’ age was corrected to match the fullterms’, who were seen at 47 weeks conceptional age, so that they were actually seen at an older chronological age. To make this correction, 39 weeks, which was the average Ballard score (5) for the fullterm group was selected as the "standard". Preterm infants’ gestational age at birth, also based on Ballard scores, were subtracted from 39 and the difference was the number of weeks which were added to infants’ chronological age to identify the "corrected age" at which testing should occur.

Maternal drug use. Maternal drug use was ascertained through maternal self-report and confirmed through EMIT (Enzyme-Multiplied Immunoassay Technique) assay urine screens of mothers and infants and reviews of medical records. Mothers were designated as "cocaine users" if they reported cocaine use and/or had a positive urine screen at any time in pregnancy, at delivery or postpartum (mother or infant screen). Many women also used alcohol and tobacco and some used marijuana. Women reporting alcohol but not cocaine use who had a urine screen free of cocaine metabolites were also included in the "drug" group. After a "case" had been identified, a "control" dyad was selected from women meeting the same criteria who denied drug and alcohol use and whose urine screens were negative.

Five sources of data were used to determine characteristics of maternal drug use during pregnancy. These were: (a) maternal medical records, which frequently contained the results of urine screens during pregnancy and delivery as well as material about maternal drug use; (b) maternal self-reports in the hospital using the Drug Checklist During Pregnancy (18); (c) maternal self report during a home visit conducted within 30 days of delivery using the Addiction Severity Index (ASI;33); (d) maternal postpartum urine screen and (e) infant urine screen, both of which were analyzed for cocaine metabolites as well as opiates and other
commonly used drugs. Perinatal urine samples were collected from 92% of the dyads in the "user" group and 96% of dyads in the nonuser group. Of the women who were assigned to the user group, 66% had one or more positive urine screens and, of those, 90% also reported cocaine use. The 34% of the women in the user group who had negative urines, admitted to cocaine or alcohol use during pregnancy. Of those assigned to the nonuser group, 100% reported no cocaine use and this was confirmed by EMIT screen in 96% of the cases. In 4% of the cases, the screen was not completed. Maternal drug use characteristics of the subsample reported on here are shown in Table 1.

Birth characteristics of children included in the 8-week study are shown in Table 2. In the neonatal period, there were significant differences in growth parameters (birth weight, length, head circumferences) as well as 1 minute and 5 minute Apgar scores as a function of gestational age. Birthweight was also significantly lower in the drug-exposed group and there was an interaction between term status and drug exposure with the full term drug exposed infants being more affected. These findings are discussed fully in a paper describing this cohort in the neonatal period (12).

Procedure.

At 8-weeks postpartum, infants and caregivers who could be recontacted were invited to the Human Genetics Laboratory where the attentional procedure was administered as part of a follow-up visit. Transportation was provided by project staff. Caregivers were asked when infants normally napped and the appointment was scheduled for a period when infants were likely to be alert. As part of the research protocol, a feeding evaluation (16) was done so that all infants were bottle fed before the attentional procedure was carried out. In this population, bottle feeding is the norm and breast feeding was an exclusionary criteria for the follow-up sample both because it was uncommon but also because, among those women who use drugs postpartum, milk may transmit drugs to the nursing infant (15).

In the laboratory, mothers signed informed consent forms approved by Emory University School of Medicine’s Internal Review Board. They were interviewed by outreach workers regarding their current substance use and given a structured clinical interview (35) to ascertain the infant’s status and habits, household composition and routine, and the infants’ health care experience. To insure that reading problems would not interfere with understanding of written material, all consent forms and questionnaires were read aloud.

Following the feeding session, infants were taken to a quiet, warm room, placed on a raised cot and three cardiac leads attached on the thorax to monitor HR using a Hewlett Packard Cardiac
Monitor (Model # 788333) which converts signals to beats/minute and provides a second by second display. After observing this initial procedure, caregivers went to a different room to complete the questionnaires. Infants rested for 5 minutes and then a modified form of the Bayley Scales of Infant Development, 2nd Ed (BSID-II) (6) was administered. The BSID items were administered in a standard format involving a sequenced presentation of stimuli and HR was recorded periodically during the procedure. Because 8-week-old infants have difficulty maintaining a calm alert state, testers were allowed to soothe infants as necessary to maintain appropriate testing conditions. Infants who were unable to maintain an alert state or who cried uncontrollably were excused from the study. Infant state was assessed and recorded by a research assistant who also recorded the HR at standard intervals. All psychologists, psychometrists and research assistants were blind to the infants’ drug exposure history, term status, and outcomes of tests done in the neonatal nursery by different personnel (12).

Following the test procedure, infants were disconnected from the leads, undressed, weighed and measured, their diapers changed if necessary, and returned to their caregivers.

Measures

Caregivers. Caregivers were interviewed and administered several questionnaires. The Structured Clinical Interview (SI:35) provides information about the following areas: Demographics, Caregiving History, including involvement with protective services and alternative caregivers, Household Composition, including adult male or father’s involvement, Preparations for Baby, Household Routine, including feeding, sleeping and other activities, and Health Care arrangements (i.e., plans for routine and emergency care, vaccinations, and well baby visits). Items on the 8-week SI are clustered, based on theoretical criteria, into several domains. For this study the Caregiver Stability/Instability, and Caregiver Routine clusters were used and the items making up these clusters are shown in Table 3.

Insert Table 3 about here

Information about social support and family resources was obtained also (22,23). Women who misuse cocaine, alcohol and other drugs often report that they are estranged from family and other sources of support (40) and the lack of such support as well as financial and other resources can negatively affect ability to parent. Finally, caregivers completed the Symptoms Checklist-90-R (SCL-90-R) (20) to evaluate their emotional and behavioral status. This scale measures nine primary symptom dimensions and gives three global measures of distress including the General Severity Index (GSI) which provides information about current psychological resources.

Infants. Infants were measured in several ways including growth (weight, length, and head
circumference), neurodevelopmental status and attention. To measure cognitive and motor
development, the BSID-II (Standardization version) (6) was administered. Of the three scales
included in this measure, only the Mental Development Index (MDI) and the Psychomotor
Development Index (PDI) were used in the current study. The MDI and PDI yield standard
scores with a mean of 100 and a standard deviation of 15. At eight weeks, the infant’s
behavioral repertoire is somewhat limited so that scores at this age are not predictive of later
functioning except in extreme cases; however, the scale is useful in comparing groups.

For the current research, the "standardization" form of the BSID-II was used. This form is very
similar to the final version published in 1993 but it includes some items that were omitted from
the final version. This form was used because, at the time the study was begun, the second
edition had not been released. When the BSID was scored, the second edition forms were used
to record "passes" and the standard scores derived from the norming sample.

To allow the collection of attentional data, a protocol for BSID item administration was set up
which is somewhat more structured than that employed clinically. In this protocol, items which
could be administered to the supine infant were given first and in a predetermined order.
Following completion of these items, the examiner picked up the baby for the motor items.
Finally, the child was propped up in the research assistant’s lap and administered the "seated"
items.

The attentional protocol was experimental. To examine differential response of drug-exposed
and preterm infants to different classes of stimuli, the following procedure was used. After
being attached to electrodes to monitor cardiac functions, infants were allowed to rest until
they were drowsy or quietly alert when a baseline HR was taken. Four recording of HR were
made at 0, 15, 30 and 45 seconds. Infant state at each point was also recorded. State was
categorized into 7 levels, very similar to those used in the Neonatal Behavioral Assessment
Scale (11) except that "crying" was further differentiated into two categories, "fussy crying"
and "vigorovous crying". In this study, state was used to establish that an infant was available to
attend to stimuli. That is, the infant was in an quiet alert or active alert state when the stimulus
was presented as it has been established that such a state is necessary for the observation of
HR deceleration (42).

After a baseline rate was established, the stimulus series was presented with infants lying
supine in a quiet room in which light was provided by lamps placed outside their line of sight.
To maintain their heads at the midline so that focus would be on the presented stimuli only,
small sandbags were placed on either side of the head. During presentation of inanimate items,
the examiner stood behind the infant out of the line of sight. During the social stimulus, the
examiner moved to the side of the cot and placed herself in the infant’s line of sight. In the
same manner as for the baseline, HR was recorded with the presentation of an inanimate
auditory stimulus (bell), an inanimate visual stimulus (red ring) and an animate social stimulus
(the examiner). During the procedure, the heart rate recordings and the statements of the
examiner regarding state and stimulus onset were videotaped to allow assessment of
reliability.
Data Reduction and Analyses

To compare outcomes for the four groups of infants, repeated measures analysis of variance procedures (ANOVAs) were conducted to detect significant changes in HR (4 levels: HR at stimulus presentation, 0s, 15s, 30s, 45s) as a function of term status (2 levels: preterm versus fullterm), of drug group (2 levels: drug-exposed versus control), and significant interactions (change in HR by term status by drug group). A separate analysis was conducted for each stimulus (baseline, rattle, ring, and social). In addition, a repeated measures ANOVA was conducted to compare the HR at the initial presentation (0s) of each of the stimuli in order to see if there was a systematic change in HR from the first to the last of the stimulus presentations.

Finally, a planned hierarchical linear regression was done to examine the contribution of factors which might explain any observed group differences.

For the purposes of this analysis, HRs were recoded as difference scores using the recording at the initiation of each sequence as the baseline for that sequence. Using changes from this baseline allowed assessment of reaction to stimuli while controlling for individual differences in baseline.

In a preliminary step, factor analysis was used to create variables derived from multiple measures of theoretical constructs, particularly Caregiving Potential and Quality of Caregiving. The items entered into each factor were determined a priori based on conceptual considerations. Those items that loaded at least .40 were then standardized and averaged to form the predictor variables (see Table 4). Because there were many individuals with no drug use in this sample, statistical theory suggested that it would be most appropriate to use dichotomous variables to describe cocaine, alcohol, marijuana and tobacco exposure (17). In this analysis, predictor variables were entered in a predetermined order into a forward linear regression. The results of this analysis would determine the unique contribution in variance accounted for by each set of predictor variables (i.e., change in $R^2$).

Insert Table 4 about here

Results

Maternal Characteristics

Caregivers’ demographic and substance use characteristics are shown in Table 1. Drug and alcohol using women are significantly older than nonusers but there are no differences in education, income, marital status or ethnicity. Sixty-three percent of mothers of fullterm drug
exposed infants reported at least weekly cocaine use as well as a mean of 6.37 ounces of absolute alcohol per week (AA/wk) for this group. Mothers of preterm infants report lower rates of cocaine use but this comparison is not statistically significant. Drug use is reported in terms of weekly, rather than daily use since this "binge" pattern is most characteristic of this group of women.

Social support and SCL-90-R summary outcomes are shown in Table 5. In households where mothers used drugs in pregnancy, male caregivers are less likely to be present and there is a greater involvement with protective services. No differences are reported in access to resources or social support and all of the women are in the normal range on the Global Severity Index (GSI) of the SCL-90 as well as on all subscales of this test, which are not shown since no differences were observed.

Responses on the SI were clustered into Caregiver Routine and Stability/Instability in Caregiving. Items contributing to these clusters are shown in Table 3. A 2-factor ANOVA indicated that there were significant differences between drug-users and controls on the Instability Cluster ($F_{(1,104)} = 8.49, p < .004$) while preterm and fullterm groups did not differ. Drug users had a mean score of 2.86 items (s.d.=1.6) while nonusers had a mean of 1.98 (s.d.=1.3). Differences on Caregiver Routine did not reach significance.

Infant Characteristics

Table 2 shows the characteristics of the infants in this study in the neonatal period and Table 6, at eight weeks. In Table 6, ages of preterms are corrected. With the exception of length (fullterm, control infants are significantly longer than other groups), the growth differences seen at birth are no longer evident at two months of age. No significant differences are observed on the BSID standard scores at this age for either mental or motor development.

Attention to Stimuli.

The mean HRs for drug-exposed and control infants, both preterm and full term, are shown in Table 7. The pattern of results can be seen more clearly in Figure 1.
Using repeated measures analysis of variance procedures, the only significant difference between the groups evident at baseline is that preterm, control infants show an elevated heart rate at the last data collection point (45s) compared to the other three groups. No differences are evident in the HR response for the auditory stimuli. In the visual condition, there is an interaction of drug group and term status at the final measurement point. This outcome is not related to a deceleration response, however, which is measured by the change from 0s to 15s and 30s. In the social condition, there is a significant difference between the drug-exposed and control groups, with the drug-exposed children showing an acceleratory response and the nonexposed group showing a deceleratory response indicative of orientation and sustained attention. There is also an interaction between drug group and term status with the preterm, drug-exposed infants showing a more exaggerated acceleratory response than the full-term, drug-exposed infants while the full-term control infants show a greater deceleratory response than preterm controls.

**Regression analysis.**

To examine the contributions of caregiving (Caregiving Potential and Quality of Caregiving) and drug use to the observed differences in HR response to stimuli, hierarchical multiple regression was used with the social stimulus difference score (i.e., the change in HR at 15s from 0s) as the dependent variable (17). In a forward regression procedure, variables were added in the following order: Caregiving Potential (SES, psychological resources [GSI]); Behavior/Growth at birth, Quality of Caregiving (SI z-scores); Term status (Ballard Score: weeks of gestation); Cocaine Use (Yes/No); Marijuana Use (Yes/No); Alcohol Use (Yes/No), and Tobacco Use (Yes/No). Only Instability in caregiving (t=3.44, p<.001) and Cocaine use (t=2.02, p<.05) contributed significant variance. Instability accounted for 13.7% of the variance and cocaine exposure, 3.4%. The model as a whole was significant (F (7,97)=3.14, p<.005) with 18.5% of variance accounted for.

**Discussion**

This study was carried out to identify alterations in attention processing associated with prenatal cocaine/polydrug exposure that could be observed at eight weeks of age when acute drug effects might no longer be expected. Because maternal substance use in pregnancy is often associated with perinatal complications, including preterm birth, and with nonoptimal caregiving environments, these factors were included in the research design to explore their effects on attention. As hypothesized, infants born to women abusing substances in pregnancy showed a different pattern of response to the presentation of stimuli. However, in this study, response differences were confined to animate social stimuli. Inanimate auditory and visual...
stimuli did not demonstrate such effects. While the responses of preterm infants, as a group, did not differ significantly from those of full terms, there was an interaction, with the preterm, drug-exposed infants showing the most acceleration in HR in response to social stimuli and fullterm, control infants showing the greatest deceleration. This finding also confirms the hypothesis that infants who experience two kinds of high-risk events, prenatal exposure and preterm birth, may show more persistent consequences than those with fewer biological stressors. These findings are in contrast to those for the growth and neurodevelopmental outcomes where no differences associated with either prematurity or prenatal exposure were observed at this age.

Finding that cocaine, but not other drugs, and caregiving instability both contributed significantly to the observed differences in sustained attention to social stimuli illustrates the complexity of development in such situations. These outcomes suggest that the ability to process such information at this age is influenced both by the direct effect of cocaine exposure, which may be assumed to be affecting arousal regulation, and by parenting, which is usually believed to help the young infant in developing behavior regulation skills. For the child of a substance abuser, made vulnerable by prenatal exposure, the caregiving environment may not provide the necessary support for emotional and social development. Such patterns may be associated with later problems in regulation of behavior and social development. For the preterm infant, the vulnerability appears to be more significant although it is also possible that, since these children were older chronologically, they were exhibiting the effects of a greater duration of exposure to nonoptimal caregiving rather than to greater neurodevelopmental vulnerability.

These results are consistent with previous work, which has demonstrated effects on attention in cocaine-and polydrug-exposed infants at three months of age and older (33). However, these results extend knowledge in this area by suggesting specific factors that may underlie observed deficits in attentional processing. This pattern of findings may indicate the basis for the kind of regulatory and behavioral disorders that often are observed in the children of substance abusers. The social regulation provided by an adequate caregiving environment during the first months of life permits most children to control arousal, become accessible to their environments and to begin to interact appropriately. For the prenatally exposed infants in this study who may be subject to alterations in arousal associated with their cocaine exposure, caregiving instability exacerbates the difficulties in achieving this important milestone.

Although these results are consistent with previous work (and, perhaps, intuitively obvious) there are some limitations in the study which should be noted in interpretation of these results. Due to the experimental situation, in which a number of kinds of data were being collected, as well as the limited "patience" of infants of this age, the attention protocol itself was very simple. Procedural refinements could be made in future studies to explore these issues more elegantly. First, the stimuli were presented in a fixed order so that, if there were any fatigue effects or, conversely, if the infants became more available to process stimuli with the passage of time, these effects would be confounded with the type of stimulus presentation. To control for some aspect of this problem, a repeated measures ANOVA was done on the initial (0s) points of each sequence. No differences were found for any group across presentations suggesting that differences in level of arousal did not account for the observed results.
A second limitation is the way in which HR was measured. Simple beats per minute were calculated and recorded at 15s intervals. In fact, because the orientation response, or initial deceleration occur in the first 5 or 6 seconds, it is possible that this methodology may have missed nonsustained responses to the inanimate stimuli that occurred in a transitory manner. Because social stimuli are so salient to infants of this age in comparison to other stimuli (34), the responses may have persisted longer for this presentation and allowed observation. While this limitation does not change the findings that social stimuli are highly significant to infants of this age and that these responses differ as a function of drug-exposure and postnatal experience, it would be valuable to examine responses to other stimuli in a more fine-grained way. Another limitation on the interpretation of these results is that, for methodological reasons (17), cocaine and other drug use were treated statistically as dichotomous variables. This methodology, while conservative, does not allow exploration of the effects of exposure to greater or lesser quantities of these substances. Finally, because data were collected as a single time point, it remains unclear whether the observed results are attributable to differences in the rate of maturation of the attention process in these groups of infants or to persistent deficits in some groups.

Despite these limitations, these data provide insight into the developmental process of cocaine/polydrug-exposed infants and how the effects of their exposure may interact with their postnatal caregiving experiences. For this group of infants, social and emotional outcomes, rather than cognition and growth, have become the focus for concern. Results of this study may indicate which children are at highest risk for such negative outcomes and suggest that intervention early in infancy may be useful in preventing the development of persistent deficits.

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