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Profiles of reactivity in cocaine-exposed children

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A B S T R A C T

This study explored the possibility that specific, theoretically consistent profiles of reactivity could be identified in a sample of cocaine-exposed infants and whether these profiles were associated with a range of infant and/or maternal characteristics. Cluster analysis was used to identify distinct groups of infants based on physiological, behavioral and maternal reported measures of reactivity. Five replicable clusters were identified which corresponded to 1) Dysregulated/High Maternal Report Reactors, 2) Low Behavioral Reactors, 3) High Reactors, 4) Optimal Reactors and 5) Dysregulated/Low Maternal Report Reactors. These clusters were associated with differences in prenatal cocaine exposure status, birthweight, maternal depressive symptoms, and maternal negative affect during mother-infant interactions. These results support the presence of distinct reactivity profiles among high risk infants recruited on the basis of prenatal cocaine exposure and demographically similar control group infants not exposed to cocaine.

Children prenatally exposed to cocaine are at risk for a wide range of poor developmental outcomes (Bateman & Chiriboga, 2000; Behnke et al., 2006; Lester, LaGasse, & Brunner, 1997; Mayes, 2002). Recent studies have suggested that one particular area of concern is the effects of prenatal exposure to cocaine on regulatory processes in infants and young children. During later infancy, one of the primary developmental tasks for infants is to cope with sensory challenges from the external environment (DeGangi, DiPietro, Greenspan, & Porges, 1991). Reactivity is conceptualized as consisting of both physiological and behavioral processes. Thus, an emerging developmental task for infants is learning to modulate positive and negative emotional experiences, both behaviorally and physiologically (e.g., Kopp, 1989; Ungerer et al., 1990). Increasingly, studies have indicated that prenatal exposure to cocaine increases the risk for regulatory problems from birth into childhood. Cocaine has been shown to inhibit the reuptake of monoamines at the presynaptic junction, leading to higher concentrations of norepinephrine, serotonin, and dopamine in the synaptic cleft and higher levels of activation in the catecholaminergic systems (Gawin & Ellinwood, 1988; Nassogne, Evrard, & Courtoy, 1998). The regions of the brain that are rich in monoamines are the centers involved in reactivity to stress (Robbins, 1997; Tucker & Williamson, 1984).

During the neonatal period, cocaine-exposed neonates display signs of altered behavioral and physiological regulation including state lability, altered sleep patterns, deficits in orienting and attention, increased irritability, decreased heart rates, and greater overall heart rate variability (Chasnoff, Griffith, MacGregor, Dirkes, & Burns, 1989; Coles, Platzman, Smith, James, & Falek, 1992; Karmel & Gardner, 1996; Regalado, Schechtman, Del Angel, & Bean, 1995; Regalado, Schechtman, Del Angel, & Bean, 1996; Regalado, Schechtman, Khoo, & Bean, 2001; Silvestri, Long, Weese-Mayer, & Barkov, 1991). Beyond the neonatal period, prenatal exposure to cocaine has been associated with decreased inhibitory control (Bendersky, Gambini, Lastella, Bennett, & Lewis, 2003; Bendersky & Lewis, 1998; Mayes, Bornstein, Chawarska, & Granger, 1996), higher negative affect in a variety of paradigms (Azuma & Chasnoff, 1993; Eiden, Lewis, Croff, & Young, 2002), increased disruptive behavior (Delaney-Black et al., 2004), reduced cortisol response (Jacobson, Bihun, & Chiodo, 1999), poorer physiological regulation during a baseline period and during environmental challenge throughout the first year of life (Schuetze & Eiden, 2006; Schuetze, Eiden, & Coles, 2007; Schuetze, Eiden, & Danielewicz, 2009). Taken together, these studies indicate that cocaine exposure is associated with altered reactivity throughout infancy.

To date, however, studies on regulatory processes in cocaine-exposed infants have utilized a variable-centered approach in which group differences in individual variables (typically either behavioral or physiological) are examined. Such an approach ignores the fact that behavioral and physiological regulatory components are not independent traits but rather function as part of an integrated regulatory system within an individual (Bergman & Magnusson, 1997; Hart, Atkins, & Fegley, 2003). In contrast, a person-centered approach views an individual as an integrated whole in which individual aspects of a process are most meaningful when considered in the context of the overall functioning

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of an individual (Bergman & Magnusson, 1997). In such an approach, subgroups of individuals are identified on the basis of shared characteristics. Individuals within a subgroup are assumed to be more similar to each other than to individuals in other subgroups. Furthermore, it is assumed that membership in specific subgroups can be predicted a priori by other factors (Bergman & Magnusson, 1997). An increasing number of studies have examined regulatory profiles in nonexposed children using a person-centered approach. The majority of these studies have focused on early childhood and have primarily identified profiles on the basis of behavioral (e.g., Aksan et al., 1999; Caspi & Silva, 1995; Hill, Degnan, Calkins, & Keane, 2006; Janson & Mathieson, 2008) or physiological processes (Wilson, Lengua, Tininenko, Taylor, & Trancik, 2009). Physiological variables have been found to identify three profiles 1) an under-controlled profile which consisted of children with both low electrodermal and heart rate reactivity, 2) an over-controlled profile which consisted of children with high electrodermal reactivity and moderate heart rate reactivity and 3) a well-regulated group which consisted of children with low electrodermal reactivity and moderate heart rate reactivity (Wilson et al., 2009). Behaviorally, studies have found evidence for four distinct profiles of externalizing behaviors over time: 1) consistently high levels from 2 to 5 years of age, 2) initially high levels at 2 years of age with lower levels at ages 4 and 5 years, 3) a normative profile which consisted of moderate levels at age 2 and lower levels at 4 and 5 years of age, and 4) a low profile which consisted of children with low levels of externalizing behavior at each age (e.g., Hill et al., 2006). Similarly, a recent study found that four distinct profiles of disruptive behavior in preschool-aged children could be identified using a combination of behavioral and physiological variables (Degnan, Calkins, Keane, & Hill-Soderlund, 2008). These profiles consisted of children with 1) high levels , which were associated with high reactivity combined with low regulation from 2 to 5 years of age, 2) moderate levels, which are associated with initially high levels of disruptive behavior followed by lower levels at later ages, 3) normative, which are associated with both higher reactivity and regulation across early childhood, and 4) low levels of disruptive behavior, which consisted of children who were less reactive and more regulated across early childhood.

It is unclear, however, whether there are distinct reactivity profiles among substance-exposed children and whether these profiles exist for process variables (behavioral and physiological reactivity) as opposed to outcome variables (externalizing or disruptive behavior problems). Consequently, the first goal of this study was to explore the possibility that reactivity profiles could be identified in a sample of cocaine-exposed and demographically similar control group infants. Since a major developmental task during infancy is to cope with sensory challenges from the external environment (DeGangi et al., 1991), we selected measures that a) index both physiological and behavioral reactivity, and b) have been associated with cocaine and other substance exposure during pregnancy. The three variables selected were 1) latency to negative affect during a frustration paradigm (behavioral reactivity), 2) physiological responses during a frustration paradigm (physiological reactivity), and 3) a maternal report of their infant's predominant style of behavioral reactivity across a range of contexts (temperamental reactivity). From a theoretical perspective, these three variables, taken together, capture the essence of reactivity during infancy.

Behavioral reactivity

A number of studies have found evidence for increased behavioral reactivity among cocaine-exposed infants and children. For example, cocaine-exposed infants exhibit greater irritability and crying during habituation procedures at 3 months of age (Mayes, Grillon, Granger, & Schottenfeld, 1998), more negative expressions during the re-engagement phase of the still-face paradigm at 4 months of age (Bendersky & Lewis, 1998) and are more reactive to increases in stress during an arm-restraint procedure at 7 months of age (Eiden, McAuliffe, Kachadourian, Coles, Colder & Schuetze, 2008). In addition, cocaine-exposed boys were quicker to react with frustration (higher reactivity) during a problem solving task at 4 years of age (Dennis, Bendersky, Ramsay, & Lewis, 2006).

Physiological reactivity

Over the past several decades, the physiological correlates of individual differences in reactivity have been described in the general developmental literature (Calkins, 1997; Gunnar, 1986; Stifter & Fox, 1990). Much of this work has focused on the association between physiological indices and negative emotionality (Buss, Davidson, Kalin, & Goldsmith, 2004; Calkins & Fox, 1992; Gunnar, 1989). In particular, respiratory sinus arrhythmia (RSA), which is a measure of heart rate variability due to the influence of breathing rate, has been associated with behaviors reflecting negative emotional reactivity and temperament in infants (Calkins, 1997; DiPietro, Larson, & Porges, 1987; Fox, 1989; Stifter, Spinrad, & Braungart-Rieker, 1999). This variability in heart rate is influenced by the parasympathetic branch of the autonomic nervous system via one branch of the vagus nerve. According to Porges' polyvagal theory (Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996), the vagal system responds to both internal and external demands.

One commonly used measure of RSA quantifies changes in RSA during environmental demands (RSA regulation; Bornstein & Suess, 2000; Calkins, 1997). When an infant faces environmental demands, the myelinated vagal system optimally responds by applying a "brake" to regulate cardiac output (Porges et al., 1996) such that RSA is suppressed during stressful situations. This suppression of RSA allows heart rate to increase and the infant to meet environmental demands. Thus, RSA suppression may serve a key role in increasing an infant's orientation to exogenous stimulation, allowing the infant to coordinate internal physiological needs with environmental demands (Porges et al., 1996). Thus, greater suppression during environmental challenge is believed to be indicative of a more adaptive physiological system which facilitates the ability of infants to modulate their behavioral response to environmental challenge. RSA suppression, quantified as a negative change in RSA from baseline to environmental challenge, is associated with more optimal state regulation in infancy (DeGangi et al., 1991), decreased behavior problems in preschool-aged children (Porges et al., 1996), and more adaptive behavior during attention and affect eliciting tasks in both preschool and school-aged children (Calkins, 1997; Suess, Porges, & Plude, 1994), and during social approach (Stifter & Corey, 2001). Thus, the measurement of change in RSA from baseline to challenging situations is an important concurrent and predictive index of behavioral regulation in infants.

Temperament

Temperament is often defined as constitutionally based individual differences in reactivity and regulation (Rothbart & Derryberry, 1981). Infant temperament is often assessed using maternal report of infant behavior. Maternal reports of temperament, however, have been criticized as not reflecting the actual temperament of the child. In fact, the correspondence between maternal reports and observed temperament are often poor (correlations ranging from .10 to .40; Mangelsdorf, McHale, Diener, Godstein, & Lehn, 2000; Seifer, Sameroff, Barrett, & Krafchuk, 1994). One possible explanation for this low concurrent validity is that the frame of reference for assessing child behavior is so different in direct observations and maternal reports. Maternal reports are typically based on a wide range of child behaviors across numerous contexts over a much longer period of time (Rothbart & Bates, 1998) while laboratory assessments are typically based on child behavior at one point in time in a context that is unfamiliar to the child. Thus, Rothbart and Bates (1998) have argued that the maternal perspective