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Antenatal Depression Influences on
Negative Affectivity in 3 Month Old Infants

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Abstract

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This study sought to study the relationship between maternal depression experienced during pregnancy and negative affectivity (NA) in their infants. Specifically, the goals of the study were to investigate the timing of exposures to depression in pregnancy, as well as to examine the relative contributions of exposures to antenatal and postnatal maternal depression to infant negative affectivity. Participants were 80 primiparous women with a history of a Major Depressive Episode prior to pregnancy and their three month-old infants. Mothers were recruited by mid- pregnancy and assessed for depression monthly until the infants reached three months of age. At three months postpartum, the mothers completed the Infant Behavior Questionnaire – Revised (IBQ-R) and mother-infant feeding and play interactions were observed. Infant negative affectivity was operationally defined as the Negative Affectivity (NA) score of the IBQ-R and also observed negative affect. Infants of mothers who were depressed in the second trimester, specifically, had higher NA scores on the IBQ-R, $d = 0.52$. In regression analyses, mean antenatal BDI-II scores significantly predicted IBQ-R NA scores ($\beta = .39$), while mean postnatal BDI-II scores did not ($\beta = -.03$). Group comparisons showed that infants exposed to maternal depression both antenatally and postnatally had significantly higher IBQ-R NA scores than infants with no depression exposure, $p = .03$. These findings indicate that while exposure to both antenatal and postnatal maternal depression is associated with worse outcomes in infants, the antenatal exposure more strongly contributes to negative affectivity. In addition, antenatal exposure might have its greatest impact when the depression is during the second trimester of pregnancy.

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Depression is a common form of psychopathology found in the general population. North American surveys indicate that as many as 16% of people suffer from Major Depressive Disorder (MDD) at some point in their lifetime, with an additional 3% suffering from Dysthymic Disorder (Kessler, Berglund, Demler, Jin & Walters, 2005). The prevalence of depression is higher among women; women are found to have rates of depression 1.5 to 3 times that of men (Kessler, McGonagle, Swartz, Blazer & Nelson, 1993). Depression is also a highly recurrent form of psychopathology. Among those who experience a Major Depressive Episode (MDE), approximately 80% will experience at least one more episode in their lifetimes (Judd, 1997). Despite cultural conceptions of pregnancy as an idyllic time for a woman, pregnancy and the postpartum period are not protected from the occurrence of depression, with rates during these times being comparable to each other as well as to general rates for adult women at any point of life (Evans et al., 2001). Considering the significant probability of its occurrence, coupled with the multiple negative infant outcomes that have been linked to antenatal maternal depression (Sherryl H. Goodman & Rouse, in preparation), it is imperative that researchers pursue a greater understanding of the foundations of the negative outcomes that are laid in the prenatal environment. For if we can understand both the impact antenatal maternal depression has on infants, as well as how it exerts its influence on fetal development, we can begin to design and test interventions to ameliorate these negative outcomes.

Among the entire body of literature of studies examining the range of infant outcomes possibly affected by antenatal maternal depression, only a handful have focused on infant negative affectivity (Sherryl H. Goodman & Rouse, in preparation).

Relative to other outcomes, negative affectivity is especially important to examine because elevated levels of negative affectivity are consistently found to be part of the basis for a variety of child and adult psychopathologies. In fact, negative affectivity is the main dimension found in common between anxiety and depression, the two most prevalent forms of psychopathology, and is believed to account for much of the overlap between the two (Clark & Watson, 1991). One empirically-supported hypothesis is that individual differences in negative affectivity, manifest as early as infancy, have implications for different patterns of psychopathology (Cole & Zahn-Waxler, 1992). Viewed from the developmental psychopathology concepts of equifinality and multifinality (Cicchetti & Rogosch, 1996), negative affectivity in infancy is both an outcome, reflecting differing patterns of dysregulation in component processes, and a point of origin that has been found to develop into both internalizing and externalizing disorders in school-aged children (Bates, Bayles, Bennett, Ridge & Brown, 1991). Given this evidence, it is important to try to pinpoint the origins of negative affectivity.

Many studies have looked to the postnatal environment to find those origins and largely ignored the antenatal environment despite theory and research suggesting a role of the antenatal environment in child development as well as in the development of child psychopathology. By the time a newborn infant emerges from the womb, that infant's development has already been influenced by both genetic and antenatal factors, as well as the interplay of both. It is important to consider that those antenatal influences that may alter the development of the fetus continue to have effects on the infant, as well as the infant's interactions with its caretakers, its physical environment, and its social environment (Martin & Dombrowski, 2008). Therefore, among the myriad influences on

child development that have been the focus of scientific inquiry, antenatal influences are no less theoretically nor less practically important than their postnatal counterparts. It is the stance of this study that both environments are potentially important to the emergence of negative affectivity, and we developed and tested a model that includes both.

What then is negative affectivity? In the adult literature, it is a factor analytically-derived superordinate construct considered a mood-dispositional dimension that reflects pervasive individual differences in a propensity to experience negative emotions, as well as differentially viewing oneself through a negative lens (Watson & Clark, 1984). Specifically applied in the infant realms, Negative Affectivity, together with Surgency/Extraversion and Orienting/Regulation, comprises infant temperament (Rothbart & Derryberry, 1981). Negative affectivity is that aspect of temperament that subsumes negative emotions like fear, distress, anger, anxiety, and sadness (Derryberry & Rothbart, 2001). Negative affectivity is hypothesized to involve three neural circuits specifically related to defensive functions (Derryberry & Rothbart, 2001) . The first is the circuit implicated in fear reactivity, or more generally the fight/flight system. The second circuit involves behaviors related to frustration. This circuit is thought to be closely related to the reward-seeking approach behavior system, such that when an infant is blocked from receiving an expected reward, this neural circuit is activated (Panksepp, 1982). Compared to the more primitive fear system implicated in the first circuit, this system is higher-level and involves activation in the frontal cortex. The third circuit responds to conditioned signals to produce anticipatory anxiety. This circuit activates the behavioral inhibition system, which can serve either to inhibit the approach functions of the approach reward-seeking system or inhibit the fight/flight functions of the fear

system. Also, it can serve to redirect attention away from a distressing stimulus (McNaughton & Gray, 2000).

The behavioral correlates of the neural circuits implicated in negative affectivity are measured by the Fear, Frustration, Sadness, and Falling Reactivity subscales on the Infant Behavior Questionnaire-Revised (IBQ-R). Together these subscales comprise the Negative Affectivity index of the IBQ-R. The Fear subscale is related to anticipation of pain or distress and includes startle and other responses to stimuli (Shaw & Vondra, 1995). The Frustration subscale, also known as Distress to Limitations, includes responses to confinement and goal blocking. The Sadness subscale measures an infant's response to disappointment or loss. Finally, the Falling Reactivity subscale assesses an infant's rate of recovery from peak levels of distress. The Sadness subscale is theoretically related to the Frustration subscale in that they both tap an infant's response to loss or suffering. In fact, the two scales typically are correlated in the range of approximately 0.50 to 0.65 (Shaw & Vondra, 1995). The distinction between the two lies in the relative activity of the approach system. Those infants with more active approach systems would tend to respond to loss or suffering with angry/frustrated behaviors, while those infants with less active approach systems would respond to loss or suffering with sadness and a sense of hopelessness.

Regarding the stability of this construct, Negative Affectivity as measured by the IBQ-R has been shown to increase significantly across the first year of development. The data on the development of the IBQ-R showed that Negative Affectivity was significantly higher in their 9-12 month standardization sample than their 6-9 month standardization sample (Pearson's *r* for the effect of differences between two groups = 0.21), which was

in turn higher than their 3-6 month standardization sample (Pearson's *r* for the effect of differences between two groups = .17) (Gartstein & Rothbart, 2003). This increase is accounted for mostly by increases in Fear and Frustration, with each of these showing increases across the first year, while Sadness and Falling Reactivity show stability over this same period of time. The shift in the Fear subscale scores occurs between the 6-9 month and 9-12 month samples (r = .18), whereas the increases in the Frustration scale are significant throughout the first year (3-6 months vs. 6-9 months: r = .20; 6-9 months vs. 9-12 months: r = .23). These shifts are believed to be due to emerging cognitive skills, such that goal-directed thinking and greater long-term memory could allow for blocked goals to be kept in mind longer, resulting in greater Frustration (Gartstein & Rothbart, 2003). Also greater memory could increase Fear due to an infant remembering adverse experiences for longer periods of time. It is important to note, however, that this seeming increase with age in Negative Affectivity could also represent a detection bias, whereby temperamental differences are simply more difficult to detect at younger ages.

Why is negative affectivity in infancy important to study? Several studies have demonstrated significant links between aspects of negative affectivity in infancy and negative outcomes later in life. One longitudinal study showed that general distress measured through lab observations of infants at 3 months of age, as well as IBQ ratings of fear at 6.5, 10, and 13 months, predicted parent ratings of fearful temperament at 7 years of age; parental and laboratory ratings of fear at 6.5, 10, and 13 months predicted parent ratings of child shyness at 7 years; and parent ratings of fear at these three ages, as well as laboratory measures of fear at 13 months predicted parent ratings of child sadness at 7 years (Rothbart, Derryberry & Hershey, 2001). The same study found both parent

ratings of high distress to limitations at 3 months, and laboratory measures of distress to limitations predicted anger/frustration at 7 years. Finally, laboratory measures of frustration at 10 months predicted parent ratings of low soothability at 7 years (Rothbart et al., 2001). Similarly, laboratory observed negative affectivity at 6 months predicted internalizing problems (but not externalizing problems) on the Child Behavior Checklist (CBCL) at 2 years of age (Putnam & Stifter, 2005). Extending the developmental predictions even further, temperamental fear/shyness at age 5 years, measured with the Children's Behavior Questionnaire (the child version of the IBQ-R), predicted CBCL internalizing scores (but not externalizing scores) at 17 years of age (Leve, Kim & Pears, 2005). Thus although fear, shyness, anger/frustration, and behavioral inhibition in infants are not psychopathological in and of themselves, they are the temperamental underpinnings of internalizing disorders like anxiety and depression.

Turning from the endpoints of the negative developmental trajectory to its origins, the literature supports two primary mechanisms whereby depression during pregnancy may contribute to temperamental differences in infants, especially negative affectivity. The first and most supported mechanism is through alterations in the pregnant women's regulation of the hypothalamic-pituitary-adrenal (HPA) axis, thought to be influenced by depression and the often accompanying stress (C. P. Cowan & Cowan, 1988). It is hypothesized that HPA axis dysregulation associated with depression and stress causes elevations in the levels of glucocorticoids, specifically cortisol, in the mother during pregnancy. The glucocorticoids are believed to act on the fetus in two primary ways 1) by crossing the placenta directly to impact fetal growth and development, including the development of the central nervous system and brain structures and 2) by constricting

uterine blood flow, thereby diminishing the delivery of oxygen and nutrients to the developing fetus, possibly resulting in premature birth, lowered birth weight, shorter newborn length, and complications of birth (C. P. Cowan & Cowan, 1988). Despite the wide acceptance of the glucocorticoid mediation hypothesis, few studies have been able to validate the theory applied directly to antenatal depression and infant temperament, although the link between higher levels of maternal cortisol and negative temperament has been made in well mothers (P. A. Cowan & Cowan, 2003). Specifically in depressed mothers, Davis et al. (2007) found that 2-month old infants' negative affectivity was significantly associated with elevated maternal cortisol at 30-32 weeks gestation, but not cortisol measured at 18-20 weeks or at 24-26 weeks. The second hypothesized mechanism whereby depression during pregnancy may contribute to the development of infant negative affectivity is through poor maternal health behaviors. Depression in pregnancy is associated with decreased likelihood to seek out prenatal care and adhere to prescribed prenatal care regimens (Lia-Hoagberg et al., 1990). Antenatal depression is also associated with poor weight gain during pregnancy and increased use of cigarettes, alcohol, and cocaine (Zuckerman, Hortensia, Bauchner & Cabral, 1989). One study found that depressed pregnant women were twice as likely than non-depressed pregnant women to indicate by self-report that they had poor health and functional status (Orr, Blazer, James & Reiter, 2007). However, we found no papers that examined the mediating role of health behaviors in associations between antenatal depression and infant negative affectivity. In general, studies of depression in pregnancy, including this one, typically control for negative health behaviors, like smoking, substance use, etc., prohibiting a test

of an association between antenatal maternal depression and infant negative affectivity via poor health behaviors.

Although testing mechanisms is not the topic of this study, theorizing about the mechanism informs the hypotheses to be tested. Looking broadly at how antenatal depression might be related to infant negative affectivity, both of the proposed mechanisms work similarly -- by affecting the development of brain systems and neural circuits. Looking more closely, the pathway to negative affectivity in the infant could be reached in several ways, as would be suggested by the developmental psychopathology construct of equifinality (Cicchetti & Rogosch, 1996). First, elevated glucocorticoid exposure could result in the programming of the HPA axis in the fetus, such that the infant would be overly reactive to stressors. In infancy, stressors confronted in everyday life are mostly either in the form of a stimulus that elicits fear (e.g. exposure to a novel person, object, or sound) or in the form of a limitation of a reward-seeking behavior (e.g. not being fed at the moment that hunger emerges). An overly reactive HPA axis could be activated in both types of situations, and might result in exaggerated fearful and/or frustrated behaviors typical of negative affectivity in infancy. Glucocorticoid exposure could also decrease the proliferation of the hippocampus, which is rich in cortisol receptors, thereby impairing the regulatory feedback function of the hippocampus in the HPA axis (Weinstock, 2005). Glucocorticoid exposure may also interfere with the optimal development of the amygdala and limbic system in the fetus. All three of these regions are implicated in the behavioral inhibition system, which when dysregulated can result in anticipatory anxiety, fearful inhibited behavior, and decreased inability to

regulate negative emotions by redirecting attention away from unpleasant stimuli towards more pleasant stimuli.

Second, through the constriction of uterine blood flow due to elevated levels of maternal cortisol or through poor health behaviors, it is hypothesized that developing fetuses are deprived of essential blood and nutrients that in turn negatively impacts growth and development, including those important neural structures discussed in the previous paragraph. A recent study of children born healthy at term found that small body size and shorter body length at birth were associated with both the externalizing (anger/frustration) and the internalizing (discomfort and sadness) components of negative affectivity in five and a half year-old children (Pesonen et al., 2006). Further support for this finding comes from another study that found that smaller size at birth predicted higher levels of social fear and internalizing problems in preschool-aged children (Talge, 2008). Additionally, a population-based study found a statistically significant association between maternal depression during pregnancy and newborns' low birth weight (95% CI of Pearson's r [.06, .33]) (Evans, Heron, Patel & Wiles, 2007) . These findings are consistent with a developmental trajectory from antenatal depression to infants' smaller size at birth to negative affectivity.

Given some evidence in support of mechanisms, it is not surprising that a small body of studies shows strong evidence for a positive association between antenatal depression and infants' greater negative affectivity. The studies varied on the nature of the populations sampled, the way in which depression was measured, and the timing in pregnancy when depression was measured. Given interest in potential critical periods of exposure, that topic is covered separately in the following paragraph. Here we review the

overall findings, regardless of when antenatal depression was measured. We identified six studies that examined the associations between antenatal depression and infant temperament in the first year of life. Of these six, five found significantly poorer temperament outcomes for these children. Specifically, these studies found antenatal depression to be associated with greater infant difficulty (Austin, Hadzi-Pavlovic, Leader, Saint & Parker, 2005; Cutrona & Troutman, 1986), greater observed negative reactivity (Davis et al., 2007; Davis et al., 2004), and greater negative affect (Huot, Brennan, Stowe, Plotsky & Walker, 2004). The one study (Leerkes & Crockenberg, 2003) that did not achieve statistical significance found a small effect size (0.15) in associations between antenatal depression and infant's distress to limitations that was in the same direction as the other findings. Statistical significance may have been constrained by a small sample size. All of these studies except for one measured temperament within the first 6 months of life. The Huot study measured negative affectivity in a sample of children ranging from 3 months to 7 years using the IBQ, together with the Early Childhood Behavior Questionnaire and the Childhood Behavior Questionnaire, which are two other temperament measures also developed by Mary Rothbart, analogous to the IBQ in older samples.

Of these six studies, only two also examined the timing of depression in pregnancy, with both finding that earlier exposure was more strongly associated with infant negative affectivity relative to later exposure. Huot et al. (2004) found that depression in the first or second trimester (combined due to the small sample of women depressed during the first trimester) was significantly associated with negative affectivity while depression in the third trimester was not. In fact, the overall significant association

they found between antenatal depression, regardless of when it occurred, and infant negative affectivity was explained by earlier depression. In contrast, the Davis et al. (2007) study, found significant although small associations between antenatal depression and infant negative reactivity regardless of whether depression was measured during the 5th month (18-20 weeks) (r = .18) , the 7th month (24-26 weeks) (r = .13) or the 8th month (30-32 weeks) (r = .14) month of pregnancy. The limited and mixed findings on timing of exposure to prenatal depression in relation to infant negative affectivity are consistent with the findings from an extensive review of the antenatal stress literature, which concluded that a timing effect of stress in pregnancy was variable and therefore difficult to isolate to a specific critical window in pregnancy (Van den Bergh, Mulder, Mennes & Glover, 2005).

Just as important as an infant's antenatal experience is the environment into which it is born, especially its relationship with caregivers. The postnatal parenting environment provided by a depressed mother can be deficient or even stressful to their infants in any number of ways. For example, a depressed mother may lack sensitive responsiveness to her infant's needs; she may be disengaged or display flat affect; she may expose the baby to negative affect; or she may even display behaviors that are intrusive to the infant. As was noted in a 2000 meta-analytic review by Lovejoy, Gracyk, O'Hare, and Neuman , there are numerous studies that have found each of the aforementioned deficits in the quality of parenting by depressed mothers, including lower maternal sensitivity (Shaw & Vondra, 1995), disengagement and flat affect (Lyons-Ruth, Zoll, Connell & Grunebaum, 1986), negative affect (Campbell, Cohn & Meyers, 1995), and intrusiveness (Nolen-Hoeksema, Wolfson, Mumme & Guskin, 1995). The meta-analysis found that across 46

studies, depressed mothers showing significantly less positive affect and more negative affect in their interactions with their children (Lovejoy et al., 2000). These parenting deficits are among the possible mechanisms mediating the relationship between postnatal maternal depression and adverse infant outcomes, including negative affectivity.

There is a significant body of literature exploring adverse outcomes relevant to negative affectivity for children of postnatally depressed mothers, in contrast to the fairly limited body of literature examining of the relationship between antenatal depression and negative affectivity. The literature that examines the infants of postnatally depressed women has found that maternal depression is negatively associated with infants' ability to sustain engagement and to regulate emotional states, both skills in which deficits could easily contribute to negative affect (Weinberg, Olson, Beeghly & Tronick, 2006; Weinberg & Tronick, 1998). Specifically, studies have found that infants of postnatally depressed mothers expressed more negative emotions (Whiffen & Gotlib, 1989), had higher Irritability factor scores on the Brazelton Neonatal Behavioral Assessment (Ayissi & Hubin-Gayte, 2006), had greater "difficult" temperament (Austin et al., 2005; Edhborg, Seimyr, Lundh & Widstrom, 2000), had lower frustration tolerance and greater fear of novelty (Sugawara, Kitamura, Toda & Shima, 1999), and reduced adaptability, reduced approach and great negative mood (Galler, Harrison, Ramsey, Butler & Forde, 2004). A meta-analysis of the literature up until 1993 found a moderate statistically significant association between maternal postpartum depression and "negative" infant temperament (C. T. Beck, 1996b).

A methodological limitation of the majority of studies of infant temperament in association with postnatal depression is that they fail to consider the possible contribution

of antenatal depression to their outcomes. For example, of the 17 papers cited in the Beck meta-analysis, only one paper (Cutrona & Troutman, 1986) included measures of antenatal depression in its design. This is a limitation for two reasons. One is the evidence for antenatal influences on infant negative affectivity, as reviewed here. The second concerns knowledge of the course of depression. When the epidemiological data on the course of depression in women prior to, during, and after pregnancy is considered, it becomes clear that to look only at postnatal depression is to get an incomplete picture. For example, a large U.S. cohort study showed that the strongest predictor of postnatal depressive symptoms was the presence of those symptoms during pregnancy (Rich-Edwards et al., 2006). In fact, women were almost seven times more likely (OR = 6.78) to have clinically significant symptoms of depression postnatally if they has also had experienced clinically significant levels of depressive symptoms during pregnancy. Two separate meta-analyses conducted in the area of predictors of postnatal depression support the strong role of antenatal depression (C. T. Beck, 1996a; O'Hara & Swain, 1996). The Beck meta-analysis found a correlation of 0.51 between antenatal and postnatal depression across 44 studies, and the O'Hara meta-analysis found a correlation of 0.35 between antenatal depression and postpartum depression assessed either by symptom self-report or diagnostic interview across 13 studies. Given this compelling evidence, it is possible that associations between postpartum depression and infant negative affectivity are actually explained by antenatal depression. Thus a study that would be in the best position to draw conclusions about the associations between perinatal maternal depression and child outcomes would include both antenatal and postnatal depression data.

The studies that have looked at the relative contributions of antenatal and postnatal depression are rare for any outcome, including for infant negative affectivity. Of those that prospectively examined this relationship, the previously discussed Leerkes and Crockenberg (2003) paper found no significant association between either antenatal depression (measured in the 7th or 8th month) or postpartum depression and 6-month old neonatal neurobehavioral regulation. Their study was conducted using a predominantly Caucasian, middle-class sample with depression assessed with the Center for Epidemiological Studies Depression Scale (CES-D), albeit with a modified approach to scoring. In contrast, a pair of studies out of the Davis lab but using different samples (Davis et al., 2007; Davis et al., 2004) found that while antenatal depression predicted infant negative reactivity at both infant ages 2 and 4 months, concurrent postnatal maternal depression did not. Finally, a study using a sample of predominately minority ethnicity women (Diego, Field & Hernandez-Reif, 2005) looked at behaviors in neonates between 5-13 days, like fussing/crying, indeterminate sleep, movement, and stress behaviors. They measured depression between 23-27 weeks of gestation and again concurrently with the newborn measures, and used the traditional cut-offs of the CES-D ($\geq$16) to divide their sample. They found that groups of infants exposed to antenatal depression only and exposed to both antenatal and postnatal depression did not significantly differ from one another and both were significantly worse than unexposed infants and those only exposed postnatally.

These results suggest that it is the antenatal exposure that matters more than postnatal exposure in the development of infant negative affectivity, a concept that is consistent with fetal programming theory. This theory was developed by Barker (1998) in

an effort to explain why, given two people with similar family histories and lifestyles, one develops heart disease while the other does not. The theory has been well received and applied to other fields, including developmental psychopathology. Specifically, fetal programming theory posits that insults that occur during sensitive periods of fetal development exercise organizational effects, or program "set points", on the fetus (Martin & Dombrowski, 2008). If these set points are specifically designed for certain environmental circumstances that are not those encountered by the infant, the infants' ability to adapt is hampered by these maladapted set points and can result in any number of poor outcomes, including infant negative affectivity.

Despite the importance of better understanding the relative influences of antenatal and postnatal exposure, it is also important to consider the possibility that genes might explain associations between maternal depression, regardless of when it occurs, and infant temperament. Women prone to depression might genetically pass that vulnerability on to their infants, the earliest iteration of which might appear as negative affectivity. However, findings from studies of heritability of temperament might be interpreted to suggest that there is little opportunity for heritability to explain antenatal depression influence on infant temperament, at least as exhibited during the first months of life. A study of 316 twin neonates assessed the heritability of neonatal neurobehavioral indicators such as irritability, resistance to soothing, and reactivity, and found the heritability estimates to be no different than zero (Cohen, 1988). Furthermore, they concluded that the differences in these indicators were largely due to environmental influences. However, genetic factors seem to have more influence on temperament as children mature. A longitudinal twin study found that from 12 months to 30 months, the

changes in behavioral inhibition, a component of temperament, were more concordant for the monozygotic twins than for the dizygotic twins (Matheny, 1989). That is, monozygotic twins, who have more genes in common relative to dizygotic twins, developed to be more similar to one another in temperamental factors over this period of development. By the time a child has reached early to middle childhood, heritability coefficients for temperamental differences typically range from levels of 0.2 to 0.6 (Saudino, 2005). The increase with age in heritability could again be attributed to a detection bias. In either case, a review article (Ivorra-Martinez, Gilabert-Juan, Molto-Ruiz & Sanjuan, 2007) indicated that there were high expectations from the genetics field for an explanation of temperament rooted in heritability, but that the current body of empirical evidence was equivocal. Therefore, it would seem that until more conclusive evidence comes out of the genetically-informed studies of infant temperament, fetal programming theory or some other alternative may be the better fit or at least an important part of the model.

Although the body of literature reviewed seems to suggest it is antenatal depression exposure, relative to postpartum depression exposure, that is more important in the development of infants' negative affectivity, two key questions require further study because of a number of methodological weaknesses in the literature to date. These questions include: Does the timing of antenatal depression matter in the development of infant negative affectivity? And what is the contribution, if any, of postnatal depression to this outcome? The present study is ideally situated to address these questions regarding maternal depression and infant negative affectivity and improve on knowledge by correcting for the methodological shortcomings of other studies in the area. These

include the importance of timing of antenatal depression and the relative contributions of antenatal and postnatal depression to infant negative affectivity. In particular, we improve on previous studies in that many studies of antenatal maternal depression took measurements of depression at one time point during pregnancy, often in the third trimester. Considering the empirical evidence that suggests, although equivocally, that earlier fetal exposure to maternal stressors (including depression) is associated with worse infant outcomes than later fetal exposure, studies that measure depression later in pregnancy potentially miss an important piece of the story. The study design included prospective measures of depression symptom levels and diagnostic depression status at every month prenatally from the point of entry into the study, typically by the 4th month of pregnancy, through at least the 8th month of pregnancy, allowing us to address the question of the differential impact timing of antenatal depression has on infant negative affectivity. In addition, the study included monthly measures of maternal depression after delivery, up to and including at infant age of 3 months, when infant temperament was assessed, enabling us to examine the unique contributions of antenatal and any postnatal depression, including concurrent depression, to infant negative affectivity.

Although we have measures of infant temperament at additional later time points during the first year of life (at 6- and 12-months of age), we chose to focus on the measures taken at 3 months of age. The 3-month assessment was designed to capture the results of the earliest possible exposure to any postpartum depression. Also, the literature seems to find the greatest temporal stability in the IBQ-R as a measure of infant negative affectivity before 6 months of age, possibly due to the developmental shift that occurs around 6 months in which infant frontal lobe functions are more actively involved in

infant self-regulatory behavior relevant to cognitive and affective functioning (Bell & Fox, 1994; Dawson, Hessl & Frey, 1994; Derryberry & Rothbart, 2001) and/or due to the increasing influence on temperament of genes as the infant matures. Thus we examined the construct at 3 months of age, given the evidence for stability and the opportunity to better detect the contributions of antenatal and the earliest postnatal maternal depression. Future studies will examine the same questions with regard to 6- and 12-month negative affectivity and also examine predictors of continuity or discontinuity in negative affectivity over the course of the first year.

We tested two distinct hypotheses regarding the association between maternal depression and infant negative affectivity. The first hypothesis relates to the timing of antenatal maternal depression. We expected that earlier exposure, specifically exposure in the first and/or second trimesters, would be related to greater infant negative affectivity at 3 months when compared to later exposure, specifically in the third trimester.

Our second hypothesis relates to the role of postpartum depression relative to antenatal depression in association with infant negative affectivity. The theoretical foundation of the second hypothesis is the fetal programming hypothesis, which suggests that the neural foundations of negative affectivity are laid in pregnancy via exposure to antenatal depression, resulting in a predisposition to negative affectivity at birth. The fetal programming hypothesis proposes that this predisposition is then activated through interplay with environmental stressors. The second hypothesis is further justified by the extensive literature linking maternal depression to the mothers' negative cognitions, affect and behaviors, which interfere with the mother fulfilling the child's social and emotional needs (S.H. Goodman & Gotlib, 1999). This suggests that the infants may

experience the interactions with their mothers as stressful, thereby activating their predispositions to negative affectivity. Therefore, we hypothesized that negative affectivity would be highest in infants exposed to both antenatal and postnatal depression, with those with no exposure at the opposite end of the spectrum. We also expected that those exposed antenatally but not postnatally would have greater levels of negative affectivity than those with no exposure, with the understanding that neural exposure and neural programming has left these infants ill-equipped to cope with almost any environment (Martin & Dombrowski, 2008). In addition, given the evidence that shows a relationship between birth weight and infant negative affectivity, we explored birth weight as a possible mediator of the association between antenatal maternal depression and infant negative affectivity.

Anxiety is the apprehensive anticipation of future danger, typically accompanied by dysphoria or physical feelings of tension (American Psychiatric Association, 1994). The incidence of depression and anxiety co-occurring in the general population is high, with the most conservative estimates finding that those with depression had more than three times the likelihood to meet criteria for a comorbid anxiety disorder (Lapalme, Hodgins & LaRoche, 1997). The likelihood of anxiety and depression comorbidity is similar in pregnant women, as has been found in the sample of the present study (C. P. Cowan & Cowan, 1988). Furthermore, both maternal anxiety and depression during pregnancy have been theorized to share a common mechanism of influence on the fetus – HPA axis dysregulation (Kessler, 2006). To contribute to continuing questions about the specificity of influences of depression and anxiety during pregnancy, we performed

exploratory analyses using measures of maternal anxiety in the place of measures of maternal depression.

Method

Participants

The data for the study were collected as part of the longitudinal study *Maternal Depression: Implications for Infant Development (Pregnancy, Postpartum and Newborn Development Analysis [PANDA] Project).* The 80 women represented by the data were recruited from obstetrics practices in the greater Atlanta area and through media announcements. Potential participants were screened in phases, starting with a checklist filled out by interested participants. A phone interview followed. For those who continued to meet eligibility requirements, the final step was the Structured Clinical Interview for the Diagnostic and Statistical Manual- IV Axis I Disorders – Patient Edition (SCID) (First, Spitzer, Gibbon & Williams, 1995) conducted in-person. Inclusion criteria were as follows: meeting DSM-IV criteria for a previous Major Depressive Episode (MDE), being no further along in the pregnancy than 5 months, being between the ages of 18 and 40, carrying their first child, having completed the 10^{th} grade, and being either married, cohabiting with a significant other, or some other stable living situation, and being African-American or European-American. Exclusion criteria included: experiencing active suicidal ideation; meeting DSM-IV criteria for an organic mental disorder, a substance use disorder, schizophrenia or other psychotic disorder or the presence of psychotic features, bipolar disorder, antisocial personality disorder [due to concerns about impaired maternal sensitive responding to infants (Sanders, Markie-Dadds, Tully & Bor, 2000)] , or delusional disorder; testing positive in a urine toxicology

screen; or having a pre-existing medical condition that had not been stable for at least 6 months. 30% of the women were African-American, which roughly mirrors their proportion in the Atlanta region, and the remaining 70% were European-American. The mean age was 30.26; the median household income group was $71,000-$75,000 (total range $10,000-$15,000 to $100,000+). 70% of subjects were college educated; 74% were married; all participants were living with a spouse or partner. Of the 81 infants born to these women (including one set of twins), 53% were female and 47% were male.

Procedure

Participants took part in interviews and completed questionnaires on a monthly basis from their entry into the study (typically the third or fourth month of pregnancy) through 6 months postpartum and then again at 12 months postpartum. The data through the 3-month visit were the focus of this study. Women were paid $25 at each of these visits. The full SCID was administered at the first visit during pregnancy. Only the screen and mood disorders sections were given to the women during subsequent visits (plus other modules as warranted to follow up on any positive screens). In addition to the SCID to assess for a diagnosis of a DSM-IV (American Psychiatric Association, 1994) mood disorder and/or episode, the Beck Depression Inventory-II (A. T. Beck, Steer & Brown, 1997) was administered monthly to assess depressive symptom severity. The BDI-II was also administered at 5-7 days postpartum. Mothers completed the Infant Behavior Questionnaire-Revised (IBQ-R) when the infants were 3-, 6-, and 12-months of age.

The infants accompanied their mothers to the lab at 3-, 6-, and 12-months of age, of which the data from the 3-month visit was the focus of this study. During these visits, mothers and their infants were videotaped in *feeding* and *freeplay*. These segments lasted

5 minutes each. During the 5-minute *feeding* segments, mothers held their infants in their lap while either breast or bottle-feeding. During the 5-minute *freeplay* segments, infants were placed directly across from their mothers in a car seat. Mothers were provided a box of toys and instructed to play with their baby as they would at home.

Measures

Negative Affectivity Measures

In order to have a robust picture of infant negative affectivity, two different methods were used in its measurement. The first method was through laboratory observations and independent raters; the second method was through mother ratings on the IBQ-R. Much of the temperament literature employs a combination of these two methods in capturing infant negative affectivity (Leerkes & Crockenberg, 2003; Rothbart et al., 2001). Several theorists have called for this multivariate approach (as reviewed in Bates, 1986; Kagan, Snidman, McManis, Woodward & Hardway, 2002), the advantage of which is to capture both state-like (laboratory observations) and trait-like (maternal ratings) of infant negative affectivity.

Infant observed affect coding: The videotaped segments were coded for each infant's affective behavior. The observations were coded continuously by taking note of the rating that characterized the infant's state as the observation began, then rewinding the tape and toggling in slow motion until the second at which the observer determined that an affective change had occurred; this procedure continued for the duration of the segment. Infant affective behavior codes included Approach, Withdrawal, and Neutral, and were modified from the Field et al.'s (1998) AFFEX coding system guidelines (see Appendix for the Coding Manual). Additional codes were included to account for

uninformative data, including if the infant was out of the view of the camera, a researcher entered the room, or the infant fell asleep. All raters were blind to the diagnostic history and current diagnosis of the women. All raters were trained by having multiple raters view and independently rate the same videotaped segment. Inconsistencies between the raters were discussed until they achieved a consensus. Training continued in this fashion until several segments were rated similarly by all raters. Post-training, reliability was maintained by randomly selecting 20% of the tapes to be rated by a second rater. Once again, any disagreements were discussed by the two raters until agreement was reached although the scores were not changed, allowing for calculation of inter-rater reliability. Thus at least 20% of the 3-month interactions were randomly selected and coded by another individual to assure ongoing inter-rater reliability. Kappa coefficients were calculated based on exact agreement and allowing for a 1-second window of inter-rater reaction time. For all infant segments that were coded from the 3- and 6- month visits, kappa coefficients were 0.85, yielding 90.3% agreement for behavior state coding. The statistic used for the analyses of this study is the relative duration, or the total percentage of time, the infant spent in negative states, coded as Withdrawal, within each type of paradigm. The advantage of using relative duration is that it is a statistic that controls for segments of time that were uncodeable due to various error data. This method of looking at percentage of time spent in affective states has been extensively employed in the literature (Crockenberg, Leerkes & Lekka, 2007).

The Infant Behavior Questionnaire - Revised (Cole & Zahn-Waxler, 1992). The IBQ-R is a factor-analytically derived measure of infant temperament, based on the definition of temperament posited by Rothbart and Derryberry (1981). The questionnaire contains 191

items and is typically completed by a parent, in our case the mother. The items ask the respondent to rate the infant's behavior during the past week in a variety of domains. Sample questions include: *When the baby was upset about something, how often did s/he stay upset for up to 10 minutes or longer? When being dressed or undressed during the last week, how often did the baby squirm and/or try to roll away? After sleeping, how often did the baby cry if someone doesn't come within a few minutes?* These items are scored on a 7-point scale, from 1 (Never) to 7 (Always). It yields 14 scales (Activity Level, Approach, Cuddliness/Affiliation, Duration of Orienting, Falling Reactivity, Fear, Frustration/ Distress to Limitations, High Intensity Pleasure, Low Intensity Pleasure, Perceptual Sensitivity, Sadness, Smiling and Laughter, Soothability, and Vocal Reactivity) that cluster into three overarching factor scores: Orienting/Regulatory Capacity, Surgency/Extraversion, and Negative Affectivity. Each scale is scored by calculating the mean of items determined to correspond to the construct. The number of items for each scale range from 10 to 18. Negative Affectivity, the variable of interest in this study, is calculated as the mean of four of the scales: Falling Reactivity, Fear, Frustration/Distress to Limitations, and Sadness. The range of possible scores for Negative Affectivity is 1, corresponding with low negative affectivity to 7, corresponding with high negative affectivity.

For each of the four scales that comprise Negative Affectivity, internal consistency within each of the normative sampling groups (3-6 months, 6-9 months, 9-12 months) was good, with Cronbach's alphas as follows: Falling Reactivity (0.84, 0.79, 0.83), Fear (0.90, 0.89, 0.87), Frustration/Distress to Limitations (0.81, 0.83, 0.82), and Sadness (0.85, 0.85, 0.71) (Gartstein & Rothbart, 2003). No equivalent data has been

reported for the broader factor of Negative Affectivity. Gartstein and Rothbart also reported inter-rater reliability between primary and secondary caregivers from a small sample (n = 26) was significant at $p < .01$ for Falling Reactivity (r = .69), Fear (r = .75), and Frustration/Distress to Limitations (r = .57), but not significant for Sadness (r = .27).

Depression Measures

Structured Clinical Interview for DSM-IV Axis I Disorders (SCID; First et al., 1995). The SCID is a semi-structured diagnostic interview designed to assess Axis I disorders of the Diagnostic and Statistical Manual- Fourth Edition (DSM-IV) (American Psychiatric Association, 1994). The SCID was used to assess for a past history of any psychological disorders, as well as for current diagnostic status. Trained clinicians administered the SCID, with reliability determined by a senior clinical psychologist who listened to the audiotapes of each interview and independently assigned diagnoses. The full interview covering all Axis I disorders was administered only during the first visit, and served as the final screener for entry into the study. The depression module was administered at each subsequent data collection point. The SCID ultimately yields a diagnosis as to whether or not the women met full criteria for a Major Depressive Disorder, either in the past or currently, according to the criteria outlined in the DSM-IV.

*Beck Depression Inventory-Second Edition (A. T. Beck et al., 1997).*The BDI-II is a self-report measure of depression symptom severity with 21 items. Respondents are instructed to base their answers on the past two weeks, paralleling the DSM-IV criteria of duration for a major depressive episode. Each item on this instrument is rated on a 4-point scale, ranging from 0 to 3. A total score is computed by adding the ratings across items. Depression scores ranging from 0 to 13 indicate a non-depressed individual or one

with minimal depression; 14-19 indicates mild depression; 20-28 suggests moderate depression; 29-63 indicates a severely depressed individual (A. T. Beck et al., 1997). Based on these empirically established cut scores, a score of 14 or higher was considered to be depressed. The BDI-II has been found to be both a valid and reliable measure of depression severity, with an especially high degree of content validity, construct validity, and internal consistency(A. T. Beck et al., 1997). The BDI-II has been shown to have good concurrent validity with measures of both antenatal and postpartum depression (Boyd, Le & Somberg, 2005; Steer, Scholl & Beck, 1990)

Anxiety Measures

*The State-Trait Anxiety Inventory (STAI) (Spielberger, Gorsuch & Lushene, 1970).*The STAI is a measure which assesses both trait (20 items) and state (20 items) indices of anxiety. Respondents are asked to respond to a series of descriptive statements according to how well that statement describes them along a four point Likert scale (1 = not at all, 4 = very much so). The total score is the sum across items, yielding a range of scores from 20-80 with higher scores indicating greater anxiety. For the purposes of our analyses, we only used data from the state portion of the measure because they are more comparable to our depression measures in that scores are expected to vary over time. The STAI has adequate concurrent validity and internal consistency (Spielberger et al., 1970).

Data Analytic Strategy

First we tested the degree of association between laboratory observed infant negative affectivity in play and in feeding during face-to-face interactions with their mothers and IBQ-R negative affectivity scores in order to ascertain if these could be collapsed into an overall infant NA score or were best treated separately. To test the first

hypothesis that earlier exposure to depression was associated with greater infant negative affectivity, independent samples t-tests were conducted to examine group differences in our infant NA variables by maternal depression status, defined as either meeting diagnostic criteria for a Major Depressive Episode or having clinically significant depressive symptom scores. Similar analyses were run for depression in each trimester (depressed or not in second trimester; depressed or not in third trimester).

In order to test our second hypothesis that antenatal depression was more predictive of infant negative affectivity than postnatal depression, we conducted both bivariate correlational analyses and multiple regression analyses. The predictor variables were two mean BDI-II scores, one computed from the monthly pregnancy scores and one from the months in postpartum up to infant age 3 months. We controlled for number of data collections, since the number of data collections during pregnancy was often greater than the number of data collections in the 3-month postpartum period. For all regression equations, the predictor variables were centered and a statistical interaction term was created following the widely accepted approach to testing for interaction effects using multiple regression (Van den Bergh, 1990). Following the approach taken by Davis et al. (2007), we performed bivariate correlations to establish degree of associations between infant negative affectivity and each of the two mean BDI-II scores – antenatal and postnatal. We tested the significance of the difference between these two correlations using Fisher's r to z transformations. Then, we regressed infant negative affectivity onto each of the two mean BDI-II scores. We also tested for interaction effects in these regression analyses. Then to test the next part of the hypothesis that exposure to both antenatal and postnatal depression is related to higher infant negative affectivity, we

created four groups from the sample: infants with no depression exposure, infants with only prenatal depression exposure, infants with only postnatal depression exposure, and infants exposed to depression at both times. The groups were created according to diagnostic status and/or high depressive symptoms. We then used independent samples t-tests and one-way analyses of variance with planned comparisons to examine group differences by exposure.

Finally, in order to examine the hypothesis that birth weight mediates the relationship between antenatal maternal depression and infant negative affectivity, we used a series of multiple regressions, as outlined in the work of Barron and Kenny (1986). In a meditational analysis, three correlations must be established as the first condition. For this study, those three correlations were 1) between antenatal maternal depression (as measured by symptom severity or diagnostic status) and infant birth weight; 2) between infant birth weight and infant negative affectivity (as measured by observational data or mothers' ratings); and 3) between antenatal maternal depression and infant negative affectivity. In this type of analysis, if all three of these relationships are significant, the second step is to regress infant negative affectivity onto antenatal maternal depression, controlling for infant birth weight. A decrease in the strength of the association between antenatal maternal depression and infant negative affectivity indicates mediation by infant birth weight. An increase in the strength of association disproves the meditational hypothesis.

Results

Descriptive and Preliminary Analyses

Depression during pregnancy. Using both clinician-based and participant-rated depression measures and multiple prospective data collection points during the pregnancies, we were able to characterize depression in several ways. Based on DSM-IV diagnostic criteria for a Major Depressive Episode (MDE), 32.50% (*n* = 26) of the mothers became depressed during pregnancy, while the remaining 67.50% (*n* = 54) did not meet diagnostic criteria for a MDE at any point in pregnancy. Diagnostically depressed mothers were significantly more likely to be African-American than non-depressed mothers. Using standardized cut-offs for clinically significant levels of depression measured with the BDI-II (≥14), 48.75% (*n* = 39) of the mothers reported symptoms exceeding the cut-off at any point during pregnancy, while the remaining 51.25% (*n* = 41) never reported depressive symptom levels during pregnancy that exceeded the cut-off. Of those 26 who met diagnostic criteria, all except 3 also reported elevated depressive symptoms during pregnancy. For the 3 mothers who did not report elevated depressive symptoms, we were not able to collect BDI-II data during their first trimester, which is when they experienced their MDEs. There were no statistically significant demographic differences between the two groups. Because it was the case that we did not have symptom data during the first trimester for most of the mothers in our sample, we only used the diagnostic depression data for analyses of associations between first trimester depression and infant outcomes.

Postpartum depression through 3 months. A total of 13.75% (*n* = 11) of mothers met diagnostic criteria for a MDE at some point during the postpartum period through 3 months, while the remaining 86.25% (*n* = 69) did not meet diagnostic criteria during this period. More than twice that rate, 31.25% (*n* = 25) of mothers reported elevated

symptom levels above standardized cut-offs on the BDI-II during the same period, while 68.75% (*n* = 55) did not. Of the 11 women meeting diagnostic criteria, one did not endorse depressive symptom levels above the cut-off on the BDI-II. Across pregnancy and the postpartum period through three months, 37.5% (*n* = 30) managed to not become depressed, either by diagnostic criteria or high symptom scores. 30% (*n* = 24) only experienced depression during pregnancy, 10% (*n* = 8) only experienced depression within the three months postpartum period, and 22.5% (*n* = 18) experienced at least one instance of depression during both pregnancy and the postpartum periods.

Infant negative affectivity. Infant negative affectivity was characterized in two ways: from data on rates of observed negative affect collected during face-to-face play and feeding interactions between the infants at 3-months of age and their mothers, and from Negative Affectivity scores on the IBQ-R, completed by mothers also at infant age 3 months. The relative durations of infant negative affect during the *feeding* and *freeplay* paradigms were not significantly correlated with one another. However, consistent with theories of aggregating across situations in order to best capture stable dimensions of temperament (Seifer, Sameroff, Barrett & Krafchuk, 1994), we combined the two scores to form one relative duration negative affect score across both paradigms[1]. Based on this combined infant relative duration of negative affect score, infants ranged from no time spent in negative affect to 58% of time spent in negative affect (mean 0.18, SD 0.16). Six infants were excluded from the analyses due to missing or incomplete data.

IBQ-R Negative Affectivity scores ranged from 2.49-5.66 (on a scale of 1-7), with a mean of 3.49 3.50 and SD of 0.58 0.57. The mean score for this sample was

[1] All analyses of relative duration of infant negative affect were performed combining the two paradigms and for each paradigm separately. Results are reported for the individual paradigms only when they differed from one another.

significantly higher than that of the standardization sample mean (M = 2.55), with the lowest scoring infant in our sample (2.49 2.72) being the only infant to have a score below the standardization sample mean. IBQ-R Negative Affectivity scores were not significantly associated with the infant's gestational age, gender, or ethnicity. Three infants were excluded from the analyses using the IBQ-R, due to missing or incomplete data. Relative duration of observed negative affect scores were not significant correlated with the IBQ-R Negative Affectivity scores (r = .05).

Hypothesis Testing

Hypothesis One: Depression by trimester in pregnancy and infant outcomes. In order to test the hypothesis that depression in pregnancy predicts infant negative affectivity at 3 months, we conducted a series of independent samples t-tests. Looking first across all of pregnancy, contrary to hypothesis, a comparison of infants of antenatally diagnostically-depressed mothers to their counterparts yielded no significant differences, even after controlling for ethnicity, on either observed negative affect or IBQ-R Negative Affectivity scores (see Table 1 for unadjusted means) A comparison of infants of mothers with and without high mean depressive symptom scale scores across pregnancy yielded a significant difference in relative duration of observed negative affect. This finding was in the opposite direction to what was expected, and was accounted for by group differences in *freeplay*, but not in *feeding*. The magnitude of differences in the *feeding* paradigm was moderate, using guidelines proposed by Cohen (2006). There was a trend in the expected direction toward significant differences on the IBQ-R Negative Affectivity. The magnitude of this finding was small.

For analyses of associations by trimester, we created depressed and non-depressed groups for each trimester. For the first trimester analyses, diagnostic status was used to define the groups, due to insufficient BDI-II data. For analyses by second and third trimester, the depressed group was comprised of women who had either been diagnosed with depression during pregnancy, had reported high depressive symptomatology, or both. In the first trimester, there were 16 women who became depressed, 48 women with no depression, and 16 women with missing or insufficient data. Depressed mothers were significantly less educated than their counterparts. Contrary to hypotheses, there were no significant differences in observed negative affect ratings for infants of depressed or non-depressed mothers, even after controlling for maternal education. Similarly, there were no significant differences in IBQ-R Negative Affectivity scores by maternal first trimester depression status. In the second trimester, 28 women became depressed, while 52 did not. Those who became depressed were significantly more likely to be younger, less educated, and African-American. As predicted, infants whose mothers had been depressed were significantly higher in IBQ-R Negative Affectivity. The magnitude of this difference was moderate. However, after controlling for maternal age, education, and ethnicity, the difference between groups was not significant. Also contrary to hypotheses, there were no differences in group means of observed negative affect ratings by second trimester depression status, even after controlling for maternal age, education, and ethnicity. In the third trimester, there were 20 women who became depressed, 59 women with no depression, and 1 with missing or insufficient data. These groups of women were not significantly different demographically from one another. Also contrary to hypotheses,

there were no significant differences in group means based on third trimester depression status for either infant income.

Hypothesis Two: Relative Contributions of Antenatal and Postnatal Depression to Infant Negative Affectivity. In order to test our second hypothesis that antenatal depression is more predictive of infant negative affectivity than postnatal depression, we conducted both correlational analyses and multiple regression analyses, using mean BDI-II scores in pregnancy and in postpartum up to infant age 3 months as predictor variables. Because the number of data collections in pregnancy was often greater than the number of postnatal data collections, the number of antenatal collections and the number of postnatal collections were both used as control variables in regression analyses.

Mean BDI-II scores across pregnancy through 3months postpartum were not significantly associated with maternal demographic variables. Mean antenatal BDI-II scores were significantly associated with IBQ-R Negative Affectivity scores with a moderate effect size, but not with observed negative affect (see Table 2). Mean postnatal BDI-II scores (one week through 3 months postpartum) were significantly associated with IBQ-R Negative Affectivity scores with a small effect size, but were not statistically significant associated with observed negative affect. Concurrent maternal depression scores were not significantly associated with either IBQ-R NA scores or observed negative affect. Contrary to hypothesis, the degree of correlation between mean antenatal BDI-II and IBQ-R NA was not significantly greater than the correlation between mean postnatal BDI-II and IBQ-R NA, based on Fisher's r to z transformation.

Next, regression analyses were performed with the number of antenatal data and postnatal data collections entered in the first step, and mean antenatal BDI-II scores and

mean postnatal BDI-II scores entered in the second step, so as to statistically adjust for one another, and a statistical interaction term of the two mean scores in the third step. These analyses showed that mean antenatal BDI-II scores, but not mean postnatal BDI-II scores, significantly predicted IBQ-R Negative Affectivity scores (see Table 3). The interaction term did not add statistically significantly incremental variance in predicting IBQ-R NA scores. In a similar equation with observed negative affect as the dependent variable, neither antenatal nor postnatal mean BDI-II, nor the interaction of the two scores significantly predicted observed infant negative affect (see Table 3).

To test the next pair of hypotheses, the first of which was that exposure to both antenatal and postnatal depression would be associated with greater negative affectivity relative to no depression exposure, an independent samples t-test was performed. This analysis showed significant differences in group means in the expected direction in IBQ-R Negative Affectivity scores, consistent with the hypothesis. However, the hypothesized differences for observed negative affect were not found (see Figures 1 and 2). For the second of these hypotheses, that antenatal exposure would be associated with greater negative affectivity relative to no antenatal exposure, whether or not the infant had been exposed to postnatal depression, we conducted a one-way analysis of variance with planned comparisons. IBQ-R NA scores showed a trend in the expected direction but did not reach significance, $t(74) = 1.41$, one-tailed $p =. 08$. The comparison of observed negative affect was not significant, $t(71) = 1.11$, one-tailed $p = .14$.

Finally, in order to examine the hypothesis that birth weight mediates the relationship between antenatal maternal depression and infant negative affectivity, we followed the steps of mediational analysis followed by Barron and Kenny (1986). In a

meditational analysis, three correlations must be established as the first condition. For this study, those three correlations were 1) between antenatal maternal depression (as measured by symptom severity or diagnostic status) and infant birth weight; 2) between infant birth weight and infant negative affectivity (as measured by observational data or mothers' ratings); and 3) between antenatal maternal depression and infant negative affectivity. There was a significant correlation for the third comparison between antenatal maternal depression and infant negative affectivity, specifically between IBQ-R NA and mean BDI-II score during pregnancy (see Table 2). However, after controlling for gestational age, neither of the other two requisite correlations (infant birthweight with indices of maternal prenatal depression and infant birthweight with indices of infant negative affectivity) was significant. Therefore, the first condition of mediation was not satisfied, and no further analyses were conducted.

Exploratory Analyses: The Role of Comorbid Anxiety in Infant Negative Affectivity

Anxiety during pregnancy. In order to contribute to ongoing questions about whether antenatal depression and anxiety share common mechanisms of influence on the fetus, we conducted duplicate analyses using maternal anxiety variables in the place of maternal depression variables. Using the State anxiety module of the State-Trait Anxiety Inventory (Spielberger et al., 1970), we were able to characterize clinically significant levels of state anxiety using cut-offs (>40) that while not standardized, have been used the most often in the anxiety literature (Knight, Waal-Manning & Spears, 1983). In our sample, 66.25% (n = 53) of the mothers reported symptoms exceeding the cut-off at any point during pregnancy, while 33.75% (n = 27) never reported symptoms of anxiety exceeding the cut-off at any point during pregnancy. We did not routinely administer the

anxiety module of the SCID after the initial interview, thus we were unable to characterize anxiety across pregnancy according to diagnostic criteria. Mean STAI-S scores across pregnancy (M = 34.85, SD = 8.33) were significantly correlated with mean BDI-II scores (Pearson's r = .64, one-tailed $p < .01$). During the first three months of the postpartum period, 58.75% (n = 47) of the mothers reported symptoms of anxiety exceeding the cut-off, 40% (n = 32) did not, and 1.3% (n = 1) had insufficient data. Similarly, mean postpartum STAI-S scores (M = 35.08, SD = 9.08) were significantly correlated with mean postpartum BDI-II scores (Pearson's r = .63, one-tailed $p < .01$).

Anxiety in pregnancy and infant outcomes. In order to examine whether anxiety during pregnancy, similar to our depression findings, predicted infant negative affectivity at 3 months, we conducted a series of independent samples t-tests with STAI-S data. Looking first across all of pregnancy, a comparison of infants of mothers who reported high levels of anxiety symptoms to their counterparts yielded no significant differences between groups demographically. There were no significant group differences for observed negative affect (see Table 4). In contrast, the comparison of infants on IBQ-R Negative Affectivity scores revealed significant differences, such that those in the high anxiety mothers group had higher scores than their counterparts. The magnitude of difference was moderate.

For analyses of associations by trimester, we used the accepted cut-score to create high anxiety and low anxiety groups for each trimester. For the first trimester analyses, there was not enough STAI-S data to run analyses, with only 11 women having more than one STAI-S collection during that trimester. Therefore, first and second trimester data were combined. In the combined first and second trimesters, 44 mothers formed the

high anxiety group, 37 formed the low anxiety group, and 1 had insufficient data and was excluded. There were no significant demographic differences between groups. Additionally, there were no significant differences in observed negative affect ratings for infants of high anxiety or low anxiety mothers. In contrast, there was a significant effect of moderate size for differences in IBQ-R Negative Affectivity scores by maternal first/second trimester anxiety status. In the third trimester, there were 35 women with high anxiety, 41 women with low anxiety, and 4 with missing or insufficient data. There were no significant demographic differences between groups, nor were there significant differences in group means based on third trimester depression status for observed negative affect during *freeplay*. However, there were significant effects, of small and moderate size respectively, for differences in observed negative affect during *feeding* and IBQ-R Negative affectivity scores, such that the high anxiety group infants had significantly higher scores than the low anxiety group infants.

Relative contributions of antenatal and postnatal anxiety to infant negative affectivity. The anxiety analyses for our second hypothesis – that antenatal depression is more predictive of infant negative affectivity than postnatal depression – involved both correlational analyses and multiple regression analyses, using mean STAI-S scores in pregnancy and in postpartum up to infant age 3 months as predictor variables. Because the number of data collections in pregnancy was often greater than the number of postnatal data collections, the number of antenatal collections and the number of postnatal collections were both used as control variables in regression analyses.

Mean STAI-S scores from pregnancy through 3 months postpartum were not significantly associated with maternal demographic variables. Mean antenatal STAI-S

scores were significantly associated with IBQ-R Negative Affectivity scores (see Table 5), but not with observed negative affect. Neither mean postnatal STAI-S scores nor concurrent STAI-S scores were significantly correlated with IBQ-R Negative Affectivity Scores or observed negative affect.

When both mean antenatal and postnatal STAI-S scores were entered into the second step (number of antenatal and postnatal data collections in the first step) of a regression equation with IBQ-R Negative Affectivity as the dependent variable, antenatal anxiety significantly predicted variance in IBQ-R NA scores while postnatal anxiety did not (see Table 6). Furthermore, the statistical interaction term of mean antenatal and postnatal STAI-S scores did not significantly predict variance in IBQ-R NA scores. In a similar equation with observed negative affect as the dependent variable, neither antenatal nor postnatal mean STAI-S scores significantly predicted observed infant negative affect.

Similar to our depression analyses, we created four groups from the sample: infants with no anxiety exposure, infants with only prenatal anxiety exposure, infants with only postnatal anxiety exposure, and infants exposed to anxiety at both times. The first of the analyses tested whether exposure to both antenatal and postnatal anxiety would be associated with greater negative affectivity relative to no exposure to high anxiety. An independent samples t-tests showed no significant differences in group means for observed negative affect (see Figure 3), and a nonsignificant finding with a trend in the predicted direction for IBQ-R NA (see Figure 4). The second analysis tested whether antenatal anxiety exposure would be associated with greater negative affectivity relative to no antenatal anxiety exposure, whether or not the infant had been exposed to

postnatal anxiety. A one-way analysis of variance with planned comparisons of IBQ-R NA scores was significant in the expected direction, $t(73) = 3.15$, one-tailed $p < .01$. The comparison of observed negative affect was not significant, $t(70) = 1.18$, one-tailed $p = .12$.

Discussion

Overall, our results indicate that antenatal depression predicts the temperament construct of infant negative affectivity. Furthermore, antenatal depression characterized by high symptom scale scores, rather than major depression diagnoses, was most consistently associated with infant negative affectivity. In support of our hypothesis related to timing of depression in pregnancy, there was some evidence of a timing effect of depression in the second trimester, although not after controlling for mother demographics. Related to our hypothesis regarding relative contributions of ante- and postnatal depression, postnatal depression was not an independent predictor of infant negative affectivity. In fact, despite a significant correlation between postnatal depression and infant negative affectivity, regression analyses indicated a classical suppression effect, whereby the relationship between postnatal depression and infant negative affectivity was accounted for by shared variance with antenatal depression. There was mixed evidence for infants exposed to maternal depression both ante- and postnatally being worse than their counterparts. Group comparisons showed that those infants exposed to depression at both points in time had higher negative affectivity than infants with no depression exposure. However, the statistical interaction term in the regression equation did not predict significant variance in infant negative affectivity. Thus in terms of depression symptom severity, it is antenatal depression, and not the statistical

interaction of antenatal and postnatal depression severity, that predicts infant negative affectivity. These results differed somewhat from our hypothesis in which we posited, in part, that exposure to both antenatal and postnatal depression would result in the worst outcomes. These results suggest that antenatal depression exposure carries a greater relative importance as compared to postnatal depression exposure in predicting infant negative affectivity. Also, because infant birth weight was neither statistically related to antenatal maternal depression nor to infant negative affectivity, the hypothesized mediation model was not supported. Finally, we found very little support for any of our hypotheses in analyses of the infant observed negative affect.

Regarding our finding of timing of depression in the second trimester, we have little reason to doubt the veracity of this finding, as there is no theoretical justification nor evidence from the literature to indicate that maternal demographic variables, beyond being a teenage mother or extreme poverty, is related to infant negative affectivity. Furthermore, by controlling for multiple maternal demographic variables known to be highly correlated with depression, there is the danger of "controlling out" the relationship between infant negative affectivity and maternal depression completely. Therefore, we choose to stand by this finding.

Similar to findings in general adult populations (Lapalme et al., 1997), the anxiety and depression scores both during pregnancy and the postpartum were highly correlated. Therefore, that associations between anxiety and infant negative affectivity were mostly similar in pattern to associations with depression was expected. The finding on timing of anxiety in pregnancy was one notable difference. Whereas antenatal depression group status was a significant predictor of infant negative affectivity only in the second

trimester, antenatal high anxiety status was significantly predictive of infant negative affectivity regardless of when in the pregnancy it had occurred. The difference between depression and anxiety findings cannot be explained by a more stable pattern of anxiety symptoms across pregnancy. Women were equally likely to be high in anxiety in the third trimester if they had been high in anxiety during the second trimester as they were likely to have high depressive symptoms in the third trimester if they had high depressive symptoms in the second trimester. Overall, this pattern of findings suggests that in the third trimester, there is something unique about anxiety symptoms, relative to depression, in predicting 3-month old infants' negative affectivity. In general, this finding is consistent with several studies of maternal anxiety/stress and negative infant temperament (P. A. Cowan & Cowan, 2003; Davis et al., 2007; Glover, Teixeira, Gitau & Fisk, 1999). Those studies that were designed to detect an effect of timing of anxiety in pregnancy found that anxiety at any point in pregnancy, including the third trimester, was predictive of negative infant temperament. However, studies that examined both depression and anxiety in pregnancy and found an effect of anxiety in the third trimester invariably also found an effect of depression related to negative infant temperament in the third trimester (Austin et al., 2005; Davis et al., 2007; Davis et al., 2004). Ours is the only study to have found this specific relationship between anxiety, and not depression, experienced in the third trimester and infant negative affectivity.

The findings of the present study are important in several ways. First, the findings add to the growing body of literature indicating that the temperament construct of negative affectivity in infants could have its origins in the prenatal environment. Broadly, the finding that antenatal depression is associated with infant negative

affectivity in a sample of middle SES women at risk for perinatal depression due to history of depression prior to pregnancy is consistent with the accumulating evidence from studies of antenatal depression in samples of women without similar risk. The timing effect we found of depression in the second trimester is consistent with the Huot et al. (2004) study, which found a timing effect for the first and second trimester combined in a sample of children ranging from infancy to adolescence. It is also consistent with the Davis et al. study (2007), which also found a timing effect for the second trimester. However, that study also found significant, albeit small timing effects for the first and third trimesters, which is where our findings differ. Perhaps most importantly, the timing effect we found in the second trimester has direct implications for interpretation of the findings from the Leerkes and Crockenberg (2003) study, which found no significant association between antenatal depression measured in the 7^{th} or 8^{th} month of pregnancy and infant negative reactivity. Our findings suggest that it may be inaccurate to conclude that antenatal depression was not associated with infant negative reactivity in that depression may have been measured too late in pregnancy. Finally, our finding that postnatal depression was not associated with infant negative affectivity is consistent with the published studies, including Leerkes & Crockenberg (2003), Davis et al. (2004), Davis et al. (2007), and Diego et al. (2005), which found no association between concurrent maternal depression and infant negative affectivity. The present study extends those findings by taking into account not only concurrent postnatal maternal depression, but also the cumulative exposure to postnatal depression beginning in the first week postpartum.

Thus another important contribution of this study is to highlight the importance of longitudinal studies of depression and anxiety in mothers that start in early pregnancy if not before. Studies that have focused on concurrent maternal depression and anxiety and offspring functioning could have potentially "missed" an important part of the story. Our data show that mean postpartum maternal depression and anxiety scores both significantly predict infant negative affectivity. However, when antenatal depression and anxiety respectively are added to the equations, neither postnatal depression nor postnatal anxiety significantly predict infant negative affectivity. Without the antenatal data, the conclusions drawn are incomplete. Also, these results highlight the importance of data collection at least by mid pregnancy if not earlier. While the associations between anxiety and infant negative affectivity were consistent across pregnancy, the association between depression and infant negative affectivity was specific to the second trimester rather than the third trimester. A study that had only collected depression data in the final months of pregnancy would have missed that finding.

A final contribution of this study derives from the population samples. We sampled a population of women who were relatively homogeneous in two essential characteristics. First, they were at relatively low risk for depression due to sociodemographic characteristics (e.g. poverty, teenage parenting, having multiple young children). Second, they all had a history of at least one major depressive episode prior to pregnancy. Through this sampling approach, we were better able to isolate the potential effects of depression (and anxiety) relative to other potential influences on infant negative affectivity. That the mean IBQ-R Negative Affectivity score for our sample of infants was significantly higher than the mean score in the standardization sample (Gartstein &

Rothbart, 2003) is remarkable, and may reflect a genetic vulnerability to negative affectivity conferred on infants by mothers with a history of depression. This is consistent with multiple behavioral genetics studies that support the notion of genetic transmission of interpersonal vulnerabilities for the development of psychopathology (as reviewed in Gorsuch & Key, 1974). What is more remarkable, and where the advantage of our sampling strategy becomes apparent, is that within our sample of genetically at-risk infants with atypically high levels of negative affectivity, we found a significant effect for antenatal depression exposure predicting even higher levels of negative affectivity, which speaks to the impact of antenatal depression on these infants.

The design of this study had many strengths, which allowed for a robust examination of the hypotheses. First, our sample of mothers was selected to be demographically low-risk, in order to eliminate the possibility that the stressors known to be associated with poverty or teenaged-parenting, for example, might explain our findings. Second, both of the primary constructs (maternal depression and infant negative affectivity) were measured with multiple assessments, allowing us to address both important conceptual and methodological issues. Finally, we collected our maternal depression and anxiety data at multiple timepoints through pregnancy and the postpartum period. This strategy allowed us both to assess the effects of timing of depression and anxiety on our infant outcomes and also to benefit from being able to create mean scores that reflect cumulative exposure over multiple time points rather than relying on a single score reflecting depression or anxiety at a single point in time.

The present study was not able to explicitly examine the mechanisms that have been proposed whereby depression and anxiety during depression influence the

developing fetus. However, the high degree of correlation between anxiety and depression in pregnancy, as well as findings that antenatal depression and anxiety similarly and independently are associated with infant outcomes are consistent with the theorized mechanism of glucocorticoids in that both depression and anxiety are thought to involve dysregulation of the HPA axis. The findings of similar and independent associations with both antenatal depression and antenatal anxiety are not consistent with the proposed mechanism of impaired health behaviors. We were unable to find published studies that showed anxiety in pregnancy to be associated with poor maternal health behaviors. Rather, anxiety may be associated with earlier initiation of prenatal care (Blazer, Kessler, McGonagle & Swartz, 1994). Therefore, unless depression and anxiety exert their influence via separate mechanisms, poor maternal health behavior is not a likely candidate. Considering the dearth of studies that have examined prenatal health behaviors in depressed pregnant women and the impact those behaviors have on their infants, this should be a priority for future studies seeking to test proposed mechanisms. In addition, future studies on the impact of antenatal maternal depression on infant outcomes should collect both prenatal health behavioral data in addition to prenatal maternal neuroendocrinological data, in order to examine the potential role of both proposed mechanisms relative to one another.

Limitations. One primary limitation of this study is the relative unavailability of depressive symptom measures collected in the first trimester of pregnancy, due to many women not enrolling until the second trimester. Because of this, we were constrained to diagnostic data for our analyses of first trimester depression. Thus it is possible that depression symptom levels in the first trimester might have also been associated with

infant outcomes and that we were unable to detect it. Another potential limitation is that our measure of infant negative affectivity that yielded the most significant findings is a parent report, albeit the IBQ-R, which has strong psychometric properties. A recent reliability and validity study of the IBQ-R found that convergent validity of the IBQ-R subscale Distress to Limitations and laboratory-observed anger was moderated by maternal depression, such that concordance was higher when mothers reported low versus high depressive symptoms (Baron & Kenny, 1986; Parade & Leerkes, 2008). However, our findings that neither concurrent depression (Table 2) nor concurrent anxiety (Table 5) was associated with negative affectivity scores on the IBQ-R, suggest that the role of any maternal depressive bias in our study is minimal.

The lack of significant findings with our observed negative affect in infants while engaged in feeding and play with their mothers raises questions about associations between maternal depression and observed infant negative affect. Given that we were able to code infant affect with high levels of inter-rater reliability and that similar laboratory-based sampling of mother infant interactions have been found to be valid indices of infants' behavior with their mothers (Mangelsdorf, Gunnar, Kestenbaum, Lang & et al., 1990; Pauli-Pott, Mertesacker & Beckmann, 2005), the failure to support the hypotheses with observed negative affect suggest that observed infant negative affect is better explained by other infant and/or maternal factors outside the scope of this study. For example, infant negative affect induced in the laboratory has been found to be related to maternal personality (Piccinelli & Wilkinson, 1994).Our finding that the two measures of infant negative affectivity were not correlated is consistent with Hayden, Klein, and Durbin's (2005) suggestion that observational methods and parent reports of

temperament may each have particular strengths, rather than one method being superior across the board to the other.

Clinical implications. The higher negative affectivity observed in the infants of mothers with elevated depression and anxiety in pregnancy may have implications for subsequent maladaptive behaviors in the children. Recent longitudinal validation studies of the IBQ-R have shown that the Negative Affectivity factor has moderate and statistically significant (r = .36) stability with the child version of the measure (CBQ) administered at child age 6 (Bates et al., 1991). Another recent study sought to establish convergent validity between the CBQ and the Child Behavior Checklist in 4 and 5 year olds. The CBQ Negative Affectivity factor was significantly correlated ($p < .001$) with all of the major CBCL problem scales (Total, Internalizing, and Externalizing Problems) as well as all of the DSM-oriented scales, with the smallest effect size found (r = .20) for the correlation with the ADHD subscale and the largest effect size (r = .51) found for the correlation with the Anxiety subscale (Pesonen et al., 2006). This is not to say that the infants in our study will develop maladaptive behaviors; further studies will be needed to determine longer-term outcomes. However, when considered together with our results, these studies seem to indicate that negative affectivity is a common factor in many different types of maladaptive behaviors in children, is moderately stable throughout childhood, and could have its origins in the prenatal environment. Consistent with the conclusions from a recent Academy of Medicine report (Sherryl H. Goodman & Tully, in press), the findings underscore the urgency of thorough assessment, prevention, and treatment of depression and anxiety during pregnancy, each of which should be the standard of care. Furthermore, considering the importance in our study of depressive

symptoms versus depression diagnosis, health care workers should take action with elevated symptomatology, even in the absence of a full diagnosis. Finally, researchers should work to develop effective interventions for the prevention and/or reduction of antenatal depression and anxiety and test secondary benefits to the infants, such as has been found in studies of treatment for postpartum depression (Nutt et al., 2007).

References

American Psychiatric Association. (1994). *Diagnostic and Statistical Manual of Mental Disorders (4th Ed.)*. Washington, DC: Author.

Austin, M. P., Hadzi-Pavlovic, D., Leader, L. R., Saint, K., & Parker, G. (2005). Maternal trait anxiety, depression and life event stress in pregnancy: relationships with infant temperament. *Early Human Development, 81*(2), 183-190.

Ayissi, L., & Hubin-Gayte, M. (2006). Newborn neonatal irritability and maternal post-partum depression. *Neuropsychiatrie de l'Enfance et de l'Adolescence, 54*(2), 125-132.

Barker, D. J. (1998). In utero programming of chronic disease. *Clinical Science, 95*(2), 115-128.

Baron, R. M., & Kenny, D. A. (1986). The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. *Journal of Personality & Social Psychology December, 51*(6), 1173-1182.

Bates, J. E. (1986). The measurement of temperament. In R. Plomin & J. Dunn (Eds.), *The study of temperament: Changes, continuities, and challenges* (pp. 1-12). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bates, J. E., Bayles, K., Bennett, D. S., Ridge, B., & Brown, M. M. (1991). *Origins of externalizing behavior problems at eight years of age*. Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Beck, A. T., Steer, R. A., & Brown, G. K. (1997). *Beck Depression Inventory: Second edition*. San Antonio: Texas: The Psychological Corporation.

Beck, C. T. (1996a). A meta-analysis of predictors of postpartum depression. *Nursing Research, 45*(5), 297-303.

Beck, C. T. (1996b). A meta-analysis of the relationship between postpartum depression and infant temperament. *Nursing Research, 45*(4), 225-230.

Bell, M. A., & Fox, N. A. (1994). Brain development over the first year of life: Relations between electroencephalographic frequency and coherence and cognitive and affective behaviors. In G. Dawson & K. W. Fischer (Eds.), *Human behavior and the developing brain* (pp. 314-345). New York, NY: Guilford Press.

Blazer, D. G., Kessler, R. C., McGonagle, K. A., & Swartz, M. S. (1994). The prevalence and distribution of major depression in a national community sample: the National Comorbidity Survey. *Am J Psychiatry, 151*(7), 979-986.

Boyd, R. C., Le, H. N., & Somberg, R. (2005). Review of screening instruments for postpartum depression. *Archives of Women's Mental Health, 8*, 141-153.

Campbell, S. B., Cohn, J. F., & Meyers, T. (1995). Depression in first-time mothers: Mother-infant interaction and depression chronicity. *Developmental Psychology, 31*, 349-357.

Cicchetti, D., & Rogosch, F. A. (1996). Equifinality and multifinality in developmental psychopathology. *Development and Psychopathology, 8*(4), 597-600.

Clark, L. A., & Watson, D. (1991). The tripartite model of anxiety and depression: Psychometric evidence and taxonomix implications. *Journal of Abnormal Psychology, 100*(3), 316-336.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (Rev. ed.)*. NY: Academic Press.

Cole, P. M., & Zahn-Waxler, C. (1992). Emotional dysregulation in disruptive behavior disorders. In D. Cicchetti & S. L. Toth (Eds.), *Developmental perspectives on depression* (pp. 173-209). Rochester, NY: University of Rochester Press.

Cowan, C. P., & Cowan, P. A. (1988). Who does what when partners become parents: Implications for men, women, and marriage. *Marriage & Family Review, 12*(3-4), 105-131.

Cowan, P. A., & Cowan, C. P. (2003). Normative family transitions, normal family processes, and healthy child development. *Normal family processes: Growing diversity and complexity*, 424-459.

Crockenberg, S. C., Leerkes, E. M., & Lekka, S. K. (2007). Pathways from marital aggression to infant emotion regulation: The development of withdrawal in infancy. *Infant Behavior & Development, 30*, 97-113.

Cutrona, C. E., & Troutman, B. R. (1986). Social support, infant temperament, and parenting self-efficacy: a mediational model of postpartum depression. *Child Development, 57*, 1507-1518.

Davis, E. P., Glynn, L. M., Schetter, C. D., Hobel, C., Chicz-Demet, A., & Sandman, C. A. (2007). Prenatal exposure to maternal depression and cortisol influences infant temperament. *Journal of the American Academy of Child & Adolescent Psychiatry, 46*(6), 737-746.

Davis, E. P., Snidman, N., Wadhwa, P. D., Glynn, L. M., Schetter, C. D., & Sandman, C. A. (2004). Prenatal maternal anxiety and depression predict negative behavioral reactivity in infancy. *Infancy, 6*(3), 319-331.

Dawson, G., Hessl, D., & Frey, K. (1994). Social influences of early developing biological and behavioral systems related to risk for affective disorder. *Development and Psychopathology, 6*(4), 759-779.

Derryberry, D., & Rothbart, M. K. (2001). Early temperament and emotional development. In A. F. Kalverboer & A. Gramsbergen (Eds.), *Handbook of brain and behaviour in human development* (pp. 967-988). Great Britain: Kluwer Academic Publishers.

Diego, M. A., Field, T., & Hernandez-Reif, M. (2005). Prepartum, postpartum and chronic depression effects on neonatal behavior. *Infant Behavior & Development, 28*(2), 155-164.

Edhborg, M., Seimyr, L., Lundh, W., & Widstrom, A. (2000). Fussy child--difficult parenthood? Comparisons between families with a "depressed" mother and non-depressed mother 2 months postpartum. *Journal of Reproductive and Infant Psychology, 18*(3), 225-238.

Evans, J., Heron, J., Francomb, H., Oke, S., Golding, J., & Team, T. A. L. S. o. P. a. C. S. (2001). Cohort study of depressed mood during pregnancy and after childbirth. *British Medical Journal, 323*, 257-260.

Evans, J., Heron, J., Patel, R. R., & Wiles, N. (2007). Depressive symptoms during pregnancy and low birth weight at term: longitudinal study. *British Journal of Psychiatry, 191*, 84-85.

Field, T., Pickens, J., Fox, N. A., Gonzalez, J., & Nawrocki, T. (1998). Facial expression and EEG responses to happy and sad faces/voices by 3-month-old infants of depressed mothers. *British Journal of Developmental Psychology, 16*(4), 485-494.

First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. W. (1995). *Structured Clinical Interview for DSM-IV Axis I Disorders*. Washington, D.C.: American Psychiatric Press.

Galler, J. R., Harrison, R. H., Ramsey, F., Butler, S., & Forde, V. (2004). Postpartum maternal mood, feeding practices, and infant temperament in Barbados. *Infant Behavior & Development, 27*(3), 267-287.

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the revised infant behavior questionnaire. *Infant Behavior & Development, 26*(1), 64-86.

Glover, V., Teixeira, J., Gitau, R., & Fisk, N. M. (1999). Mechanisms by which maternal mood in pregnancy may affect the fetus. *Contemporary Reviews in Obstetrics & Gynecology, 11*, 155-160.

Goodman, S. H., & Gotlib, I. H. (1999). Risk for psychopathology in the children of depressed mothers: A developmental model for understanding mechanisms of transmission. *Psychological Review, 106*, 458-490.

Goodman, S. H., & Rouse, M. H. (in preparation). Effects of Antenatal Depression Exposure: A Review.

Goodman, S. H., & Tully, E. C. (in press). Recurrence of depression during pregnancy: Psychosocial and personal functioning correlates. *Depression & Anxiety*.

Gorsuch, R. L., & Key, M. K. (1974). Abnormalities of pregnancy as a function of anxiety and life stress. *Psychosomatic Medicine, 36*(4), 352-362.

Hayden, E. P., Klein, D. N., & Durbin, C. (2005). Parent Reports and Laboratory Assessments of Child Temperament: A Comparison of Their Associations With

Risk for Depression and Externalizing Disorders. *Journal of Psychopathology and Behavioral Assessment, 27*(2), 89-100.

Huot, R. L., Brennan, P. A., Stowe, Z. N., Plotsky, P. M., & Walker, E. F. (2004). Negative affect in offspring of depressed mothers is predicted by infant cortisol levels at 6 months and maternal depression during pregnancy, but not postpartum. *Annals of the New York Academy of Sciences, 1032*, 234-236.

Ivorra-Martinez, J., Gilabert-Juan, J., Molto-Ruiz, M. D., & Sanjuan, J. (2007). [The genetics of child temperament]. *Rev Neurol, 45*(7), 418-423.

Judd, L. L. (1997). The clinical course of unipolar major depressive disorders. *Archives of General Psychiatry, 54*(11), 989-991.

Kagan, J., Snidman, N., McManis, M., Woodward, S., & Hardway, C. (2002). One measure, one meaning: Multiple measures, clearer meaning. *Development and Psychopathology, 14*(3), 463-475.

Kessler, R. C. (2006). The Epidemiology of Depression among Women. *Women and depression: A handbook for the social, behavioral, and biomedical sciences*, 22-37.

Kessler, R. C., Berglund, P., Demler, O., Jin, R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry, 62*(6), 593-602.

Kessler, R. C., McGonagle, K. A., Swartz, M., Blazer, D. G., & Nelson, C. B. (1993). Sex and depression in the National Comorbidity Survey I: Lifetime prevalence, chronicity and recurrence. *Journal of Affective Disorders, 29*(2-3), 85-96.

Knight, R. G., Waal-Manning, H. J., & Spears, G. (1983). Some norms and reliability data for the State-Trait Anxiety Inventory and the Zung Self-Rating Depression scale. *British Journal of Clinical Psychology, 22*(4), 245-249.

Lapalme, M., Hodgins, S., & LaRoche, C. (1997). Children of parents with bipolar disorder: a metaanalysis of risk for mental disorders. *Canadian Journal of Psychiatry, 42*(6), 623-631.

Leerkes, E. M., & Crockenberg, S. C. (2003). The impact of maternal characteristics and sensitivity on the concordance between maternal reports and laboratory observations of infant negative emotionality. *Infancy, 4*(4), 517-539.

Leve, L. D., Kim, H. K., & Pears, K. C. (2005). Childhood Temperament and Family Environment as Predictors of Internalizing and Externalizing Trajectories from Ages 5 to 17. *Journal of Abnormal Child Psychology, 33*(5), 505-520.

Lia-Hoagberg, B., Rode, P., Skovholt, C. J., Oberg, C. N., Berg, C., Mullett, S., & Choi, T. (1990). Barriers and motivators to prenatal care among low-income women. *Soc Sci Med, 30*(4), 487-495.

Lovejoy, M. C., Graczyk, P. A., O'Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior: A meta-analytic review. *Clinical Psychology Review, 20*, 561-592.

Lyons-Ruth, K., Zoll, D., Connell, D., & Grunebaum, H. U. (1986). The depressed mother and her one-year-old infant: environment, interaction, attachment, and infant development. *New Dir Child Dev*(34), 61-82.

Mangelsdorf, S., Gunnar, M., Kestenbaum, R., Lang, S., & et al. (1990). Infant proneness-to-distress temperament, maternal personality, and mother-infant attachment: Associations and goodness of fit. *Child Development, 61*(3), 820-831.

Martin, R. P., & Dombrowski, S. C. (2008). *Prenatal exposures: Psychological and educational consequences for children*. New York: Springer.

McNaughton, N., & Gray, J. A. (2000). Anxiolytic action on the behavioural inhibition system implies multiple types of arousal contribute to anxiety. *Journal of Affective Disorders, 61*(3), 161-176.

Nolen-Hoeksema, S., Wolfson, A., Mumme, D., & Guskin, K. (1995). Helplessness in children of depressed and nondepressed mothers. *Developmental Psychology, 31*(3), 377-387.

Nutt, D. J., Kessler, R. C., Alonso, J., Benbow, A., Lecrubier, Y., Lepine, J.-P., . . . Tylee, A. (2007). Consensus statement on the benefit to the community of ESEMeD (European Study of the Epidemiology of Mental Disorders) survey data on depression and anxiety. *Journal of Clinical Psychiatry, 68*(Suppl 2), 42-48.

O'Hara, M. W., & Swain, A. M. (1996). Rates and risk of postpartum depression-A meta-analysis. *International Review of Psychiatry, 8*(1), 37-54.

Orr, S. T., Blazer, D. G., James, S. A., & Reiter, J. P. (2007). Depressive symptoms and indicators of maternal health status during pregnancy. *Journal of Women's Health, 16*(4), 535-542.

Panksepp, J. (1982). Toward a general psychobiological theory of emotions. *Behavioral and Brain Sciences, 5*, 407-467.

Parade, S. H., & Leerkes, E. M. (2008). The reliability and validity of the Infant Behavior Questionnaire-Revised. *Infant Behavior & Development, 31*(4), 637-646.

Pauli-Pott, U., Mertesacker, B., & Beckmann, D. (2005). Comparing assessment methods of infant emotionality. *Zeitschrift fur Kinder- und Jugendpsychiatrie und Psychotherapie, 33*(2), 123-135.

Pesonen, A.-K., Raikkonen, K., Kajantie, E., Heinonen, K., Strandberg, T. E., & Jarvenpaa, A.-L. (2006). Fetal Programming of Temperamental Negative Affectivity Among Children Born Healthy at Term. *Developmental Psychobiology, 48*(8), 633-643.

Piccinelli, M., & Wilkinson, G. (1994). Outcome of depression in psychiatric settings. *Br J Psychiatry, 164*(3), 297-304.

Putnam, S. P., & Stifter, C. A. (2005). Behavioral approach-inhibition in toddlers: prediction from infancy, positive and negative affective components, and relations with behavior problems. *Child Development, 76*(1), 212-226.

Rich-Edwards, J. W., Kleinman, K., Abrams, A., Harlow, B. L., McLaughlin, T. J., Joffe, H., & Gillman, M. W. (2006). Sociodemographic predictors of antenatal and postpartum depressive symptoms among women in a medical group practice. *Journal of Epidemiology & Community Health, 60*(3), 221-227.

Rothbart, M. K., & Derryberry, D. (1981). Development of individual differences in temperament. In M. E. Lamb & A. L. Brown (Eds.), *Advances in developmental psychology* (Vol. 1, pp. 37-86). Hillsdale, NJ: Erlbaum.

Rothbart, M. K., Derryberry, D., & Hershey, K. L. (2001). Stability of temperament in childhood: Laboratory infant assessment to parent report at seven years. In V. J.

Molfese & D. L. Molfese (Eds.), *Temperament and personality development across the life span* (pp. 85-119). Hillsdale, NJ: Erlbaum.

Sanders, M. R., Markie-Dadds, C., Tully, L. A., & Bor, W. (2000). The Triple P-Positive Parenting Program: A comparison of enhanced, standard, and self-directed behavioral family intervention for parents of children with early onset conduct problems. *Journal of Consulting and Clinical Psychology, 68*(4), 624-640.

Seifer, R., Sameroff, A. J., Barrett, L. C., & Krafchuk, E. (1994). Infant temperament measured by multiple observations and mother report. *Child Development, 65*(5), 1478-1490.

Shaw, D. S., & Vondra, J. I. (1995). Infant attachment security and maternal predictors of early behavior problems: a longitudinal study of low-income families. *Journal of Abnormal Child Psychology, 23*(3), 335-357.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). Manual for the Sate-Trait Anxiety Inventory (Self-Evaluation Questionnaire). Palo Alto, CA: Consulting Psychologists Press.

Steer, R. A., Scholl, T. O., & Beck, A. T. (1990). Revised Beck Depression Inventory scores of inner-city adolescents: Pre- and postpartum. *Psychological Reports, 66*(1), 315-320.

Sugawara, M., Kitamura, T., Toda, M. A., & Shima, S. (1999). Longitudinal relationship between maternal depression and infant temperament in a Japanese population. *Journal of Clinical Psychology, 55*(7), 869-880.

Talge, N. M. (2008). Size at birth and its relation to negative affectivity and HPA activity in young children (Doctoral dissertation, University of Minnesota, 2008). *Dissertation Abstracts International, 69*(9-B), 6365.

Van den Bergh, B. R. (1990). The influence of maternal emotions during pregnancy on fetal and neonatal behavior. *Journal of Prenatal & Perinatal Psychology & Health, 5*(2), 119-130.

Van den Bergh, B. R., Mulder, E. J., Mennes, M., & Glover, V. (2005). Antenatal maternal anxiety and stress and the neurobehavioural development of the fetus and child: Links and possible mechanisms. A review. *Neuroscience & Biobehavioral Reviews, 29*(2), 237-258.

Watson, D., & Clark, L. A. (1984). Negative affectivity: The disposition to experience aversive emotional states. *Psychological Bulletin, 96*(3), 465-490.

Weinberg, K. M., Olson, K. L., Beeghly, M., & Tronick, E. Z. (2006). Making up is hard to do, especially for mothers with high levels of depressive symptoms and their infant sons. *Journal of Child Psychology and Psychiatry, 47*(7), 670-683.

Weinberg, K. M., & Tronick, E. (1998). The impact of maternal psychiatric illness on infant development. *Journal of Clinical Psychiatry, 59*, 53-61.

Weinstock, M. (2005). The potential influence of maternal stress hormones on development and mental health of the offspring. *Brain, Behavior and Immunity, 19*(4), 296-308.

Zeman, J., Cassano, M., Perry-Parrish, C., & Stegall, S. (2006). Emotion regulation in children and adolescents. *Developmental and Behavioral Pediatrics, 27*(2), 155-168.

Zuckerman, B., Hortensia, A., Bauchner, H., & Cabral, H. (1989). Depressive symptoms during pregnancy: Relationship to poor health behaviors. *American Journal of Obstetrics and Gynecology, 160*, 1107-1111.

Tables and Figures

Table 1

Infant Negative Activity by Maternal Depression Group in Pregnancy and by Trimester

	Observed negative affect				IBQ-R Negative Affectivity			
	M (SD)	*t* (df)	Sig.[1]	Effect size[2]	M (SD)	*t* (df)	Sig.	Effect size
Group	Overall pregnancy							
Depressed (SCID)	.15 (.14)	1.10 (73)	.14	0.27	3.60 (0.51)	0.97 (76)	.17	0.24
Not depressed (SCID)	.20 (.16)				3.46 (0.60)			
Depressed (BDI-II)	.14 (.15)	2.10 (73)	.02	0.49	3.61 (0.62)	1.67 (76)	.05	0.38
Not depressed (BDI-II)	.22 (.15)				3.40 (0.50)			
	1st trimester							
Depressed[3]	.14 (.14)	1.25 (58)	.11	0.37	3.70 (0.44)	0.91 (58)	.22	0.23
Not depressed	.20 (.15)				3.53 (0.66)			
	2nd trimester							
Depressed[4]	.15 (.15)	1.08 (73)	.14	0.27	3.67 (0.67)	2.17 (76)	.02	0.52
Not depressed	.19 (.16)				3.38 (0.50)			
	3rd trimester							
Depressed[4]	.16 (.16)	0.80 (72)	.21	0.21	3.61 (0.50)	0.99 (75)	.16	0.27
Not depressed	.19 (.15)				3.45 (0.60)			

[1]One-tailed
[2]Cohen's d
[3]Using DSM-IV diagnostic criteria
[4]Using either DSM-IV diagnostic criteria or high depressive symptomatology according to the BDI-II

Table 2

Intercorrelations Among Indices of Maternal Depression and Infant Negative Affectivity

Measure	1	2	3	4	5
1. Mean antenatal BDI-II	-	.58**	.52**	-.10	.43**
2. Mean postnatal BDI-II		-	.89**	.04	.19*
3. Concurrent BDI-II			-	.03	.19
4. Observed negative affect				-	.05
5. IBQ-R NA					-

*$p < .05$; **$p < .01$

Table 3

Summary of Hierarchical Regression Analysis for Maternal Depression Variables Predicting Infant Negative Affectivity

	Measure of infant negative affectivity			
	Observed negative affect		IBQ-R NA	
Predictor	ΔR^2	β	ΔR^2	β
Step 1	.04		.10*	
Control variables[a]				
Step 2	.02		.13**	
Mean antenatal BDI-II		-.17		.39**
Mean postnatal BDI-II		.15		-.03
Step 3	.01		.00	
Mean Antenatal BDI-II x Mean Postnatal BDI-II		-.09		.05
Total R^2	.06		.23**	
n	75		78	

[a]Control variables included the number of prenatal BDI-II data collections and the number of postnatal BDI-II collections through 3 months.
*$p < .05$. **$p < .01$

Table 4

Infant Negative Activity by Maternal Anxiety Group in Pregnancy and by Trimester

	Observed negative affect				IBQ-R Negative Affectivity			
	M (SD)	*t* (df)	Sig.[1]	Effect size[2]	M (SD)	*t* (df)	Sig.	Effect size
Group	Overall pregnancy							
High Anxiety	.19 (.16)	0.71 (73)	.24	0.18	3.62 (0.58)	2.82 (76)	<.01	0.68
Low Anxiety	.16 (.15)				3.24 (0.50)			
	1st trimester/2nd trimester combined							
High Anxiety	.17 (.14)	0.64 (72)	.26	0.15	3.61 (0.62)	2.19 (75)	.02	0.51
Low Anxiety	.20 (.17)				3.33 (0.49)			
	3rd trimester							
High Anxiety	.21 (.17)	1.25 (71)	.21	0.11	3.59 (0.49)	2.43 (72)	.01	0.58
Low Anxiety	.16 (.14)				3.32 (0.49)			

[1]One-tailed
[2]Cohen's *d*

Table 5

Intercorrelations Among Indices of Maternal Anxiety and Infant Negative Affectivity

Measure	1	2	3	4	5
1. Mean antenatal STAI-S	-	.58**	.60**	-.04	.32**
2. Mean postnatal STAI-S		-	.82**	-.10	.09
3. Concurrent STAI-S			-	-.06	.08
4. Observed negative affect				-	.05
5. IBQ-R NA					-

*$p < .05$; **$p < .01$

Table 6

Summary of Hierarchical Regression Analysis for Maternal Anxiety Variables Predicting Infant Negative Affectivity

	Measure of infant negative affectivity			
	Observed negative affect		IBQ-R NA	
Predictor	ΔR^2	β	ΔR^2	β
Step 1	.05		.07	
Control variables[a]				
Step 2	.01		.08*	
Mean antenatal STAI-S		0.08		0.34*
Mean postnatal STAI-S		-0.14		-0.13
Step 3	.00		.03	
Mean Antenatal STAI-S x Mean Postnatal STAI-S		0.03		.18
Total R^2	.06		.18*	
n	75		78	

*$p < .05$

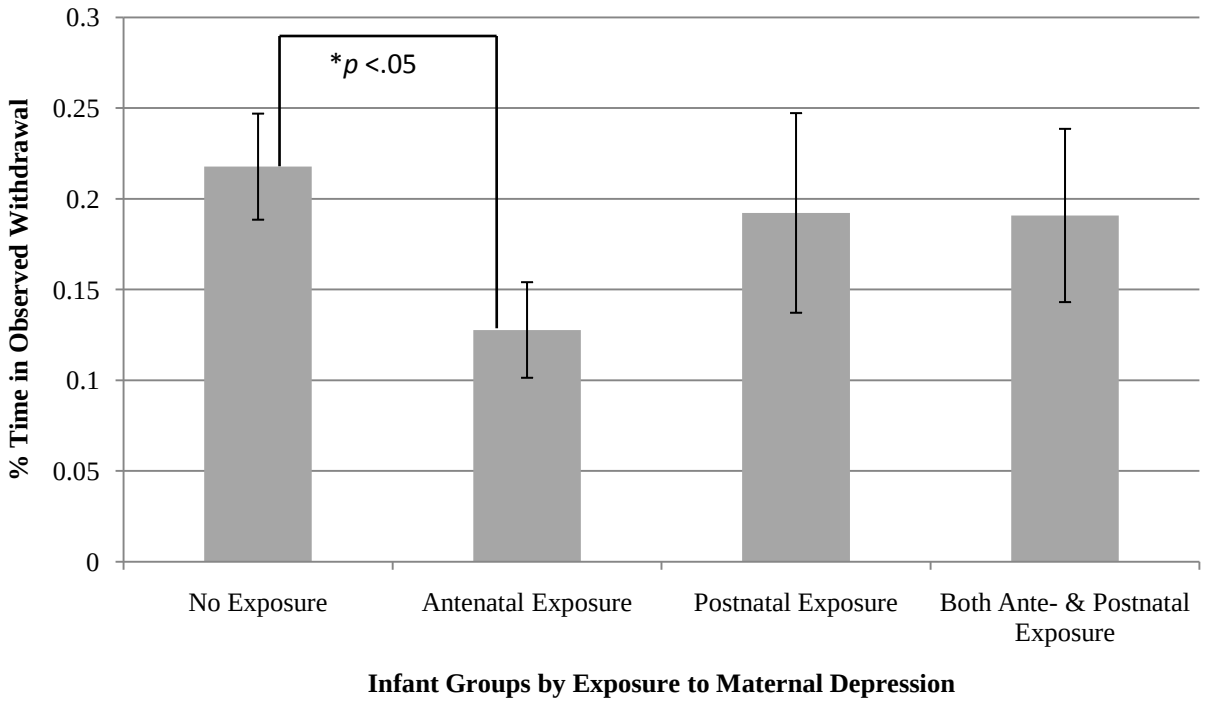

Figure 1. Mean relative duration of infant observed negative affect for infants with no depression exposure (*n* = 27), only antenatal exposure (*n* = 23), only postnatal exposure (*n* = 7), and both exposures (*n* = 15).

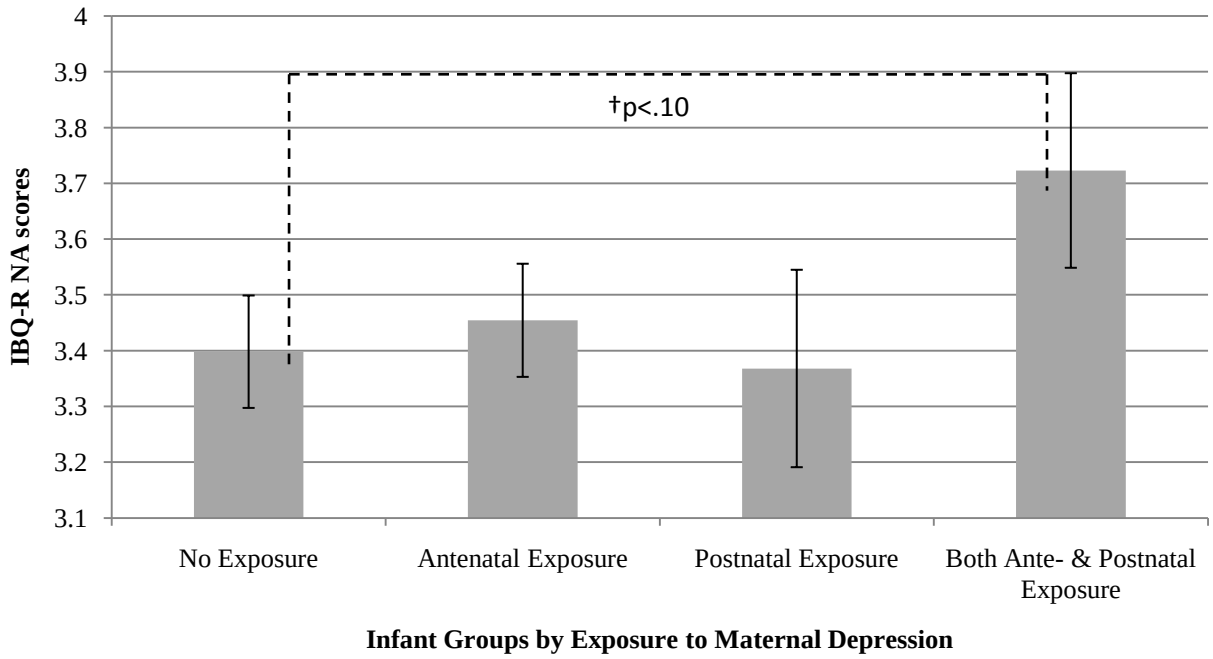

Figure 2. Mean IBQ-R NA scores for infants with no depression exposure (*n* = 27), only antenatal exposure (*n* = 23), only postnatal exposure (*n* = 7), and both exposures (*n* = 15). Note: y-axis does not start at zero

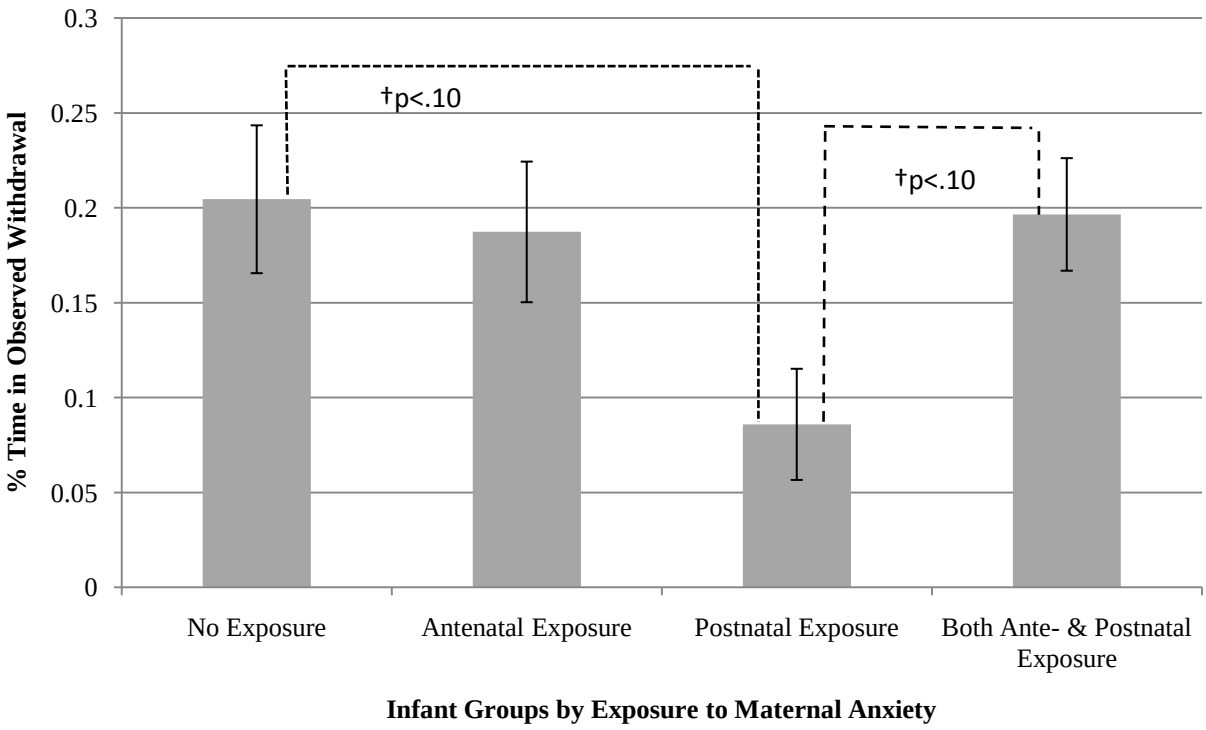

Figure 3. Mean relative duration of infant observed negative affect for infants with no anxiety exposure (*n* = 17), only antenatal exposure (*n* = 16), only postnatal exposure (*n* = 8), and both exposures (*n* = 30).

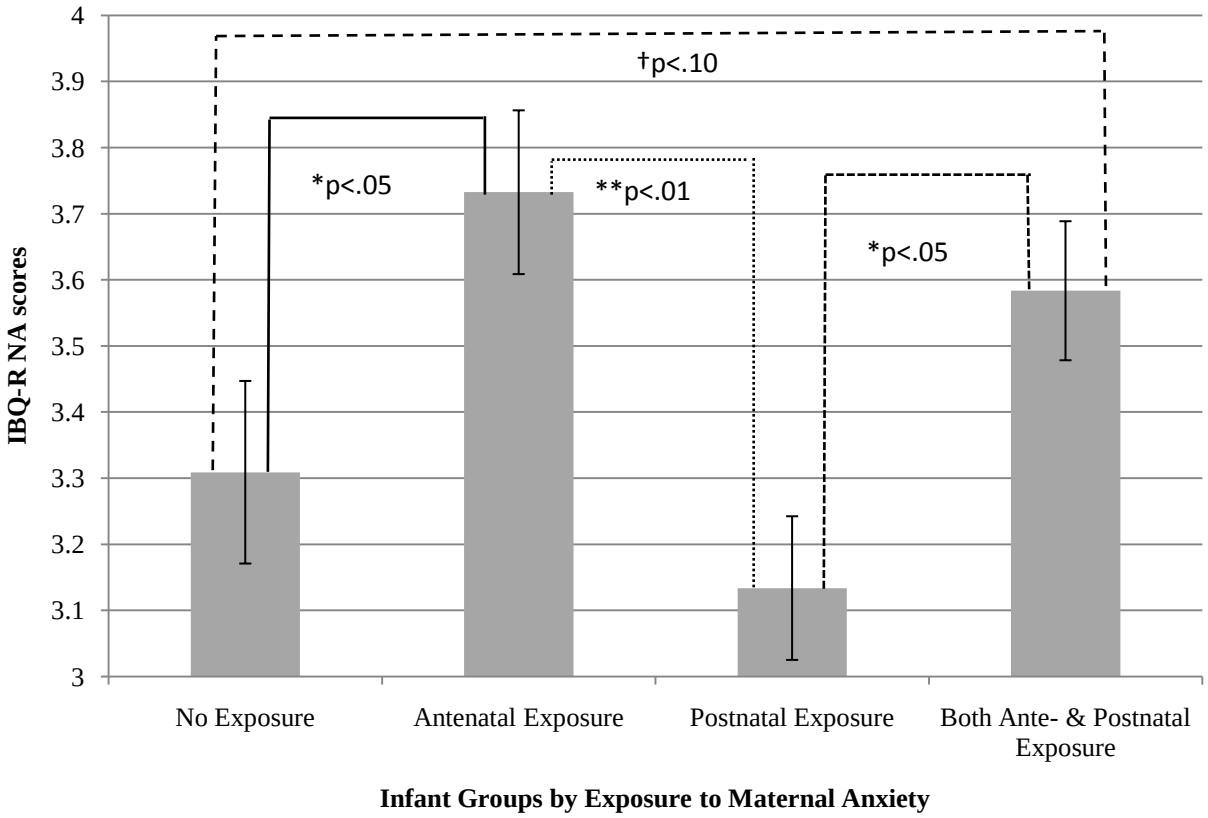

Figure 4. Mean IBQ-R NA scores for infants with no anxiety exposure (*n* = 17), only antenatal exposure (*n* = 16), only postnatal exposure (*n* = 8), and both exposures (*n* = 30). Note: y-axis does not start at zero

Appendix A

Behavioral Functioning of the Infant

Codes:
In addition to Approach (**A**), Withdrawal (**W**), and Neutral (**N**), which are defined in the table below, we will also allow for the following:

1. Uncodeable (**U**): use this only when the infant is out of view AND you have no vocal cues to the emotion for at least 3 seconds. Uncodeable would end as soon as a codeable emotion is observed.
2. Sleep (**S**): use this only when the infant is clearly in a sleep state and thereby not expressing emotions.
3. Not rateable (**X**): use this when there are circumstances that violate the standards for the particular situation you are observing, such as when there are other people in the room or the mother is not following instructions (e.g. mother playing with a toy with the infant during baseline).
4. Approach (A) during feeding segment: use when infant and mom are maintaining eye contact and one or more of the positive emotion markers or cues are present.

	Positive or *Approach* **A**	Negative/Sad or *Withdrawal* **W**	**Neutral** **N**
Specific emotion expressions	Happy/joy Surprise Positive engagement with mom or object in addition to the presence of one or more positive marker	Sadness Distress	Quiet alert
Facial markers	Smiles, cheeks raised, eyes crinkling, noticeable increase vigor with feeding	Grimace, squinting eyes, rubbing eyes, quivering mouth, furrowed brow, frown, wrinkled forehead	Eyes open, alert, focused (on mother or object) Raised eyebrows in absence of other positive affect signs
Vocal cues	Giggle, laugh, shriek or squeal, Coos?	Fuss, whimper, protest or cry or pre-cry, grunt	Coo with no indication of positive
Body cues	Limb movement (in the context of coos, giggles)?	Thrashing, head side to side, looking away/gaze aversion, arching back, stiffness	Still, calm, focused gaze, body at rest or slow, rhythmic movements