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Object perception in 5-month-old infants of clinically depressed and nondepressed mothers

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ABSTRACT

Five-month-old infants of clinically depressed and nondepressed mothers were familiarized to a wholly novel object and afterward tested for their discrimination of the same object presented in the familiar and in a novel perspective. Infants in both groups were adequately familiarized, but infants of clinically depressed mothers failed to discriminate between novel and familiar views of the object, whereas infants of nondepressed mothers successfully discriminated. The difference in discrimination between infants of depressed and nondepressed mothers is discussed in light of infants' differential object processing and maternal sociodemographics, mind-mindedness, depression, stress, and interaction styles that may moderate opportunities for infants to learn about their world or influence the development of their perceptucognitive capacities.

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1. Introduction

Infants of depressed mothers have different experiences from infants of nondepressed mothers (Field, 1992), and those experiences appear to have ramifications for infants' perception, cognition, and socioemotional development. For example, de Haan, Belsky, Reid, Volein, and Johnson (2004) reported a relation between the emotional environment provided by mothers (as indexed by affective measures of their personality) and their 7-month-olds' sensitivity to facial expressions (as indexed by visual attention and event-related potentials), and Bornstein, Arterberry, Mash, and Manian (2011) reported that 5-month infants of nondepressed mothers discriminated between neutral and smiling facial expressions of a face, whereas infants of clinically depressed mothers failed to make the same discrimination. These studies matched infants' social experience with their social perception and discrimination.

Perhaps expectedly, infants of depressed mothers experience difficulty processing and discriminating faces and facial expressions (see also Hernandez-Reif, Field, Diego, Vera, & Pickens, 2006). However, research that compares children of depressed and nondepressed mothers has also uncovered links between depression status in mothers and more generally compromised perceptual and cognitive functioning in children (Sohr-Preston & Scaramella, 2006). For example, children of depressed mothers, relative to children of nondepressed mothers, manifest attentional deficiencies (Weissman, Leckman, Merikangas, Gammon, & Prusoff, 1984; Winters, Stone, Weintraub, & Neale, 1981), such as inferior scores on the orientation cluster of the NBAS (Abrams, Field, Scafidi, & Prodromidis, 1995; Field et al., 2004; Lundy et al., 1999); they process information more slowly (Field et al., 2004; Hernandez-Reif, Field, Diego, & Largie, 2002; Hernandez-Reif, Field, Diego, & Largie, 2003) and learn contingency with greater difficulty (Kaplan, Bachorowski, Smoski, & Hudenko, 2002; Stanley, Murray

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& Stein, 2004); they score lower on the MDI and PDI of the Bayley Scales (Cornish et al., 2005), even when behavior during the test, general behavioral problems, birth weight, parental IQ, measures of the family climate and home environment, and breast-feeding during infancy are taken into account (Cogill, Caplan, Alexandra, Robson, & Kumar, 1986; Sharp et al., 1995) and have more problem-solving deficits (Hay, Zahn-Waxler, Cummings & Iannotti, 1992); they score lower on tests of cognitive-developmental milestones (Murray & Cooper, 1997); and they suffer lags in school readiness (NICHD, 1999). Thus, the capacities of infants and young children of clinically depressed mothers may be broadly compromised.

Most germane to the present study, Murray (1992) reported that infants of postnatally depressed mothers had low scores on 9-month Stage IV and 18-month Stage V object concept tasks. The infant's understanding of the permanence of objects has been described by many theorists to depend on an ability to direct attention to cues in the environment in an effort to find invisible or partially visible objects. As such, individual differences in attention and perception appear to play a significant part in passing or failing object permanence tasks such as those administered by Murray (1992). Moreover, it appears that this deficit may be continuing: children ages 6–10 years of parents with childhood-onset depression display subtle deficits in selective attention (Pérez-Edgar, Fox, Cohn, & Kovacs, 2006). Indeed, residual consequences to mother–child interactions or children's cognitive and socioemotional development are acknowledged to persist even after depression has remitted or been treated successfully (e.g., Forman et al., 2007; Nylen, Moran, Franklin, & O'Hara, 2006).

In the present study, we extended this general line of work on nonsocial perception downward and compared young infants of mothers with a history of clinical depression and of nondepressed mothers on a basic component in object perception. Sensitivity to variations in object representation is a fundamental ingredient in object perception, and so of accurate object recognition, identification, and processing. Normally, infants are skilled at such a task (e.g., Arterberry & Yonas, 2000; Bornstein, Ferdinandsen, & Gross, 1981; Bornstein, Gross, & Wolf, 1978; Bremner, 1994; Mash, Arterberry, & Bornstein, 2007; Slater & Johnson, 1998; Slater, Morison, & Somers, 1988). Research indicates that as early as 2–3 months of age infants (of nondepressed mothers) can reliably discriminate a range of object perspective, including as fine as 10° disparities between different orientations (Bornstein, Krinsky, & Benasich, 1986). Although abilities to recognize objects and make fine discriminations based on their features improve as acuity and stereovision develop (e.g., Yonas, Arterberry, & Granrud, 1987), experience exerts rapid as well as lasting influences on early visual development. Taken together, the literature suggests the hypothesis that infants of nondepressed mothers will discriminate perspectival variation of an object, whereas infants of depressed mothers might be challenged in making a similar discrimination. We tested this hypothesis. Each infant in this study was familiarized to a single view of an object and, following familiarization, tested for discrimination of the same object in a novel view.

The present study attempts to advance the extant literature on object perception in infants of depressed versus nondepressed mothers with the following features. (a) Measures of maternal depression (symptom report vs. clinical diagnosis) add to variability in the field. Most studies enlist infants of mothers with self-reported depressive symptoms (typically using a scale of symptoms experienced over the previous week and administered on the maternity ward shortly after delivery) and so do not provide an affirmed clinical diagnosis. Here we first identified mothers with a history of depressive symptomatology and subsequently selected into the study only those who received a diagnosis of clinical depression as defined by extensive interview. (b) Brief maternal depression does not appear to impact infant performance so much as chronic depression (Cornish et al., 2005). As their duration and number of depressive symptoms increase, mothers report fewer child-oriented concerns and positive emotions and more parent-oriented negative emotions; mothers also display less supportive behavior (Dix, Gershoff, Meunier, & Miller, 2004). Variation in the operational definition of maternal depression reduces the comparability of findings across studies and may account for some of the variation in results concerning the effects of maternal depression on child development. Here we studied infants of mothers who had experienced clinical depression in the lifetime of their infant. (c) In most studies of infants of depressed mothers, depression and low SES, both of which independently undermine infant performance, are confounded (Sharp et al., 1995). Here we assessed infants of clinically depressed and nondepressed mothers from comparable middle-SES families. Mothers were also the same age and parity. (d) Many perinatal factors are known to affect development, and thus the links between the mother illness and child attainments could be explained by children's pre-existing vulnerability. Here, infants in depressed and nondepressed maternal groups were term, normal birth weight, and healthy. (e) Most studies of object perception use images of objects normally known to infants (thereby ceding control over the independent variable). Here we used images of wholly novel objects equally unknown to all infants. (f) Finally, existing studies have tested relatively easy discriminations between different objects. Here we asked if infants could make finer discriminations of different perspectives of the same object.

2. Methods

2.1. Participants

Thirty-six infants (M age = 155.22 days, SD = 6.28; 18 girls) participated. Infants of clinically depressed and nondepressed mothers did not differ in age or birth weight. The sample was 78% European American, 11% Asian American, 8% African American, and 3% Latin American. An additional 7 infants began the procedure, but their data were not included due to inattention or fussiness (5), experimenter error (1), or equipment failure (1). Clinically depressed and nondepressed mothers were the same age (M = 32.67 years, SD = 4.58) and the same marital status, equal numbers of clinically depressed and nondepressed mothers were working, and among those who were working clinically depressed and nondepressed mothers

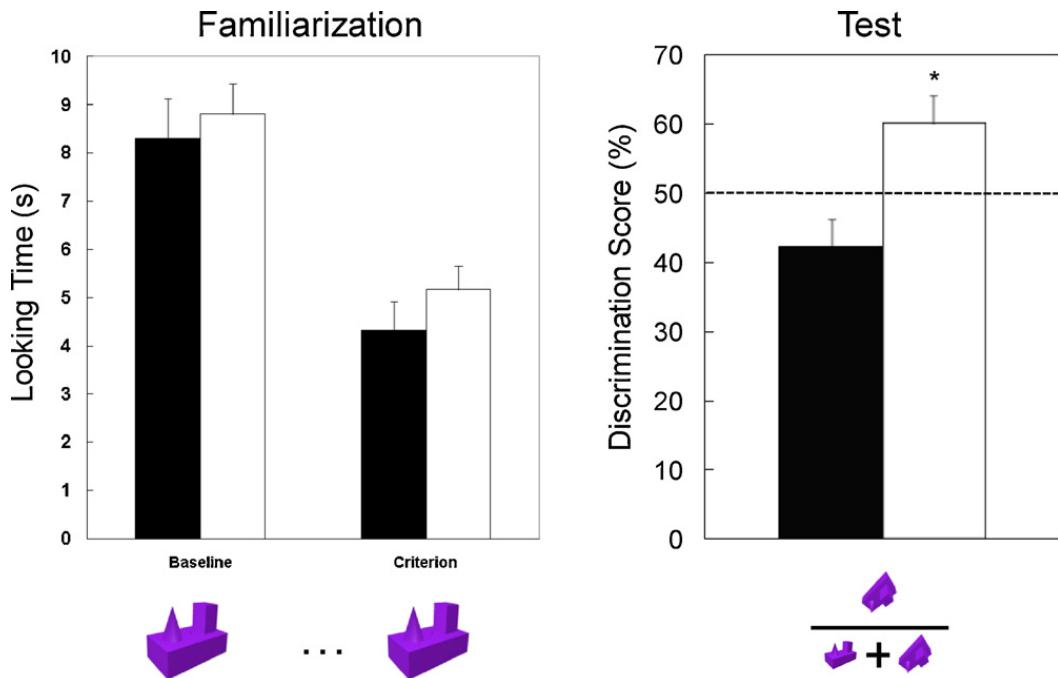


Fig. 1. Mean looking time (s) in familiarization (left) and discrimination score (%) in the test (right) for infants of clinically depressed (■) and nondepressed (□) mothers. * $p < 0.05$.

did not differ in the number of hours they worked. Socioeconomic status was measured with the Hollingshead (1975; see Bornstein, Hahn, Suwalsky, & Haynes, 2003) Four-Factor Index of Social Status, resulting in a sample mean of 57.5 ($SD = 7.1$) and did not differ between clinically depressed and nondepressed mothers.

Infants and mothers were recruited via mass mailings to new parents in a large metropolitan catchment area. Between 4 and 20 weeks postpartum, the Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996) was mailed to potential participants. The BDI-II is a 21-item self-report questionnaire of established validity (Steer & Beck, 2000). Mothers who had low (1–7) and high scores (>12) on the BDI-II were subsequently interviewed between 3 and 5 months postpartum with the structured clinical interview for DSM-IV Axis I Disorders (SCID-I; First, Spitzer, Gibbon, & Williams, 2001). At this interview, the definition of a "current" episode of major or minor depression was modified to "within the lifetime of the child." Mothers diagnosed as having had a clinically significant depressive episode in the 5-month lifetime of their infants were selected into the clinically depressed group. Seventeen infants had mothers who had been diagnosed with clinical depression,¹ and 19 infants had nondepressed mothers. Experimenters who conducted the laboratory procedures with infants were blind to maternal depression status and hypotheses of the study.

2.2. Materials and apparatus

Graphic images representing two perspectives of a single novel object were used (Fig. 1). The object consisted of a brick-shaped solid with a cube and cone attached to its top surface. For familiarization, the object was repeatedly presented in one perspective. To create a test stimulus, the object was rotated 120° around its horizontal axis. The height of the object images subtended 11.2° of visual angle, with their width varying between 12.2° and 18.3° across the two perspectives. Two additional images were used. One, an unrelated geometric image that consisted of a red square, yellow circle, and blue triangle presented against a white background, was used to index infants' attention at the beginning (pre-familiarization) and end (post-test) of the session; the other, a dynamic image of a merry-go-round presented between trials, was used to maintain infant attention to the spatial location of the stimuli.

2.3. Procedure

Infants were seated directly in front of the stimulus display at a viewing distance of approximately 36 cm in a dimly lit room. On each trial, the orienting merry-go-round image appeared first, and the experimenter observed the infant's fixation in a video monitor. The experimenter initiated the presentation of each trial after the infant was judged to be fixating the merry-go-round. To employ a design that would be sensitive to group differences (Hunter, Ames, & Koopman, 1983) we used a fixed-trials familiarization procedure (8 10 s⁻¹ trials) rather than a habituation infant-control procedure.

¹ Forty-eight percent of the women who scored high on BDI-II did not have a clinical episode of depression within the lifetime of their infants.

On the first trial, the pre-familiarization image was presented. Infants then viewed the familiarization stimulus on trials 2–5. Following familiarization, two test trials were administered in a counterbalanced design: one with the stimulus shown during familiarization and the second with the same stimulus rotated 120° over its horizontal axis. Following the 2 test trials, the post-test image was presented, completing the session. The intertrial interval varied according to the time required for the infant to reestablish fixation, but generally did not exceed 3 s.

A video camera, located above the stimulus display, captured the infant's face and the light from the display, and its video signal was shown on a monitor for an experimenter who scored infant looking on-line. Infant fixation of each image was coded using a corneal reflection technique. On all trials, the experimenter pressed a timing key to indicate when a reflected image was superimposed over the pupil and released the key when the reflection moved off the pupil with each change in fixation. The infant began to accumulate looking time when judged to look at the image for a minimum of 1 s and to terminate a look the infant had to look away from the image for a minimum of 2 s. To examine coding reliability of the primary experimenter, a second experimenter coded infants' looking times from video records for 20% of the sessions. Over individual trials and sessions, $r = 0.95$.

3. Results

Preliminary analyses revealed no significant main effects for or interactions with infant gender or stimulus order. Thus, analyses were conducted combining data.

3.1. Familiarization

To test whether infants were familiarized, we first compared looking times on the first two familiarization trials, averaged to create a baseline, and looking times on the last two familiarization trials, averaged to create a criterion (Fig. 1 left). Infants' mean looking times on the baseline and criterion trials were then analysed in a 2×2 ANOVA with maternal group (clinically depressed, nondepressed) as a between-infants factor and trial (baseline, criterion) as a within-infants factor. The analyses revealed a main effect for trial, $F(1, 34) = 74.31, p < 0.001$, partial $\eta^2 = 0.69$. No other main effects or interactions were significant. The main effect for trial was due to significantly more looking on the baseline ($M = 8.55$ s, $SD = 3.13$) than on the criterion ($M = 4.74$ s, $SD = 2.30$) trials, collapsed across maternal groups. In addition, infants in the two groups did not differ in the total amount of looking during familiarization (M infants of clinically depressed mothers = 19.41 s, $SD = 9.06$, and M infants of nondepressed mothers = 21.77 s, $SD = 6.85$, respectively), $F(1, 34) = 0.79$, ns. Finally, no differences were found between infants of clinically depressed and nondepressed mothers for looking times during the pre-familiarization or post-test, revealing uniformity between groups in their maintenance of attention throughout the task, $F(1, 34) = 0.18$, ns.

3.2. Test

Infants' mean looking times to the novel and familiar perspectives of the object in the test were converted to a traditional discrimination score by dividing the amount of time infants spent looking at the novel perspective of the object in the test by the total amount of their time looking during the test (Fig. 1 right). Infants' discrimination scores were compared to chance (50%). The mean discrimination score for infants of clinically depressed mothers was marginally less than chance, $t(16) = -2.10, p = 0.052$ (two-tailed), whereas the mean discrimination score for infants of nondepressed mothers was significantly greater than chance, $t(18) = 2.42, p = 0.027, d = 0.63$ (two-tailed). Discrimination scores differed significantly between the clinically depressed and nondepressed groups, $t(34) = 3.18, p = 0.003$, and $d = 1.06$.

4. Discussion

Five-month-olds of clinically depressed and nondepressed mothers did not differ in their initial or overall attention to the same object during a familiarization procedure. However, the two groups differed in their discrimination between two perspectives of the same object, with infants of nondepressed mothers discriminating and infants of clinically depressed mothers failing to discriminate.

These differential results in basic object discrimination prompt two questions: first, how best to interpret the different patterns of infant looking in the test and, second, why such different patterns might arise. On the first question, infants of nondepressed mothers unambiguously discriminated the change in object perspective. This result is consonant with the task demands and with the existing literature on infant object perception (Arterberry & Yonas, 2000; Bornstein et al., 1978, 1981; Bremner, 1994; Mash et al., 2007; Slater & Johnson, 1998; Slater et al., 1988). However, infants of clinically depressed mothers did not make the same discrimination. These results also parallel the existing literature in abilities of children of depressed mothers. For example, in a post habituation test comparing the face and voice of their mother and a female stranger, infants of depressed mothers failed to discriminate a novel stranger relative to their mother, whereas infants of nondepressed mothers did so successfully (Hernandez-Reif et al., 2002).

In our study design infants were familiarized with one stimulus. We think it is more probable that, under these conditions, infants of clinically depressed mothers failed to discriminate the change in object perspective and less probable

that they generalized familiarization from the familiar stimulus at criterion into the test. First, it could be that the failure of discrimination demonstrated by infants of depressed mothers is actually a generalization and indicates better performance by revealing broader recognition. However, the discrimination of an object's orientation in space is vital for establishing and maintaining a functional interface with that object (Gibson, 1979). The possibility that test-trial generalization in the present task indicates better performance is inconsistent with this functional viewpoint, especially given that typical 5-month-olds are within a phase of rapid development of manual action and its planning. By 7 months, infants take advantage of object orientation to prepare their reaches in advance of contact (Lockman, Ashmead, & Bushnell, 1984). Second, normally in infants, multiple familiarization stimuli are required to engender a generalization from familiarization. Kellman (1984) and Bornstein et al. (1986) found that, when 4-month-olds were habituated to the same stimulus pattern rotated in several different orientations, infants did not show increased looking to the familiar stimulus in a new orientation (but dishabituuated to an entirely new form). In our study with a single familiarization stimulus, infants of clinically depressed mothers failed to discriminate a change in the stimulus. Indeed, third, infants of clinically depressed mothers tended (provocatively) to show a "familiarity effect" following familiarization (Hunter & Ames, 1988); at $p=0.052$, their discrimination score was marginally *below* chance. A preference for familiarity versus novelty can be found at any age in infancy and usually depends on task difficulty relative to the age, experience, and capacity of the infant and the previous familiarization. Infants of clinically depressed mothers may lag behind those of nondepressed mothers in their object discrimination abilities.

On the second question of why different capacities for discrimination might arise, we can only speculate. Maternal depression is a multidimensional syndrome, and possible causes may reside in the infants, in the infant's respective experiences, and in interactions between the two. Infants of clinically depressed mothers suffer dysregulation in their biochemistry, physiology, and behavior (e.g., Field, 1998; Hernandez-Reif, Field, Del Pino, & Diego, 2000). Rose, Gottfried, Carminar, and Bridger (1982) found novelty preferences in 3½- to 6½-month-olds after longer periods of familiarization, but they found familiarity preferences after shorter familiarization periods, and Hunter, Ross, and Ames (1982) found that 12-month-olds who had habituated to an array of toys subsequently preferred to explore a novel array, whereas infants who were interrupted prior to completing habituation subsequently preferred to explore the familiar toys. Hunter et al. (1983) examined infants' relative preference for familiar or novel stimuli following either habituation or brief familiarization with stimuli that were either simple or complex relative to age (for 8- and 12-month-olds both arrays contained 3 toys, and for 12-month-olds both arrays contained 5 toys). Prior to testing, half of the infants in each group had been habituated to the familiar array, whereas the other half had been familiarized but interrupted before habituation could be completed. Habituated infants in each group preferred to look at and manipulate toys in a novel array. In contrast, interrupted infants preferred toys in a familiar array, but only if the array was complex relative to their age. This study provides evidence of a progression from familiarity preference to novelty preference that is not tied to a particular age but occurs as new stimuli are encountered. The direction of exploratory preference is jointly determined by amount of previous familiarization, age-related complexity, and response type.

Infant individual differences may also play a part. For example, infants of depressed mothers have been reported to have higher stress hormones (cortisol levels), and it is plausible that cortisol could account for their poor performance. Infants of clinically depressed mothers also have systematically different experiences from infants of nondepressed mothers. Notably, compared to nondepressed mothers, clinically depressed mothers harbor different cognitions and provide their infants with different rearing and interaction experiences (Field, 1992), and, possibly in consequence, infants of clinically depressed mothers perceive, function, and respond differently from infants of nondepressed mothers (Manian & Bornstein, 2009). For example, mothers' ability to consider and support their infant's perceptual cognitive processes (as indicated by their "mind-mindedness") might manifest itself in infants' perceptuocognitive deficiencies. Mind-mindedness is presumed to indicate mothers' inclination to "treat their infant as an individual with a mind" (Meins, Fernyhough, Fradley, & Tuckey, 2001, p. 638) and to reflect on experience from the child's perspective (McQuaid, Bigelow, McLaughlin, & MacLean, 2008; Meins et al., 2001). Mind-minded mothers consider their infants as having their own desires, thoughts, and intentions, and hold a comprehension of their infants' mental lives. When young infants manifest a desire, thought, or intention, it is often related to an external object. Given that mind-minded mothers, by definition, pay careful attention to their child's line of thinking, they are more likely to reflect a thorough interpretation of their child's current mental activity with accompanying context (for example, "You want a cup of orange juice", "You like this animal, it's a giraffe"). Mind-minded mothers appear likely to be sensitive to their child's current level of understanding and to adjust their discourse accordingly.

Finally, clinically depressed mothers show more withdrawn and intrusive, but also less responsive, interaction styles (e.g., Cohn, Matias, Tronick, Connell, & Lyons-Ruth, 1986; Field, Diego, & Hernandez-Reif, 2009; Murray, Kempton, Woolgar, & Hooper, 1993; Stein, Gath, Bucher, Bond, Day, & Cooper, 1991) and provide their infants with less optimal levels of general stimulation (Field, 1998; Murray, Hipwell, Hooper, Stein, & Cooper, 1996). The symptoms that characterize maternal depression (sadness, negative affect, loss of interest in daily activities, fatigue, difficulty concentrating, and bouts of withdrawal and intrusiveness) may interfere with consistent, attentive, and responsive caregiving, thereby disrupting effective and supportive parenting (Paulson, Dauber, & Leiferman, 2006). In addition, concomitant characteristics of maternal depression, such as comorbid anxiety or the intake of anti-depressants perinatally, may be involved (e.g., Lovejoy, Graczyk, O'Hare, & Neuman, 2000). In the present sample, of the 17 depressed mothers, 5 were on current antidepressants (and breastfeeding), and 5 had taken antidepressants during pregnancy. It is possible that the transfer of antidepressants, either in utero or via breastfeeding, impacts child cognitive development although several studies have questioned this effect showing that this is not the case

(Nulman et al., 2002; Yoshida, Smith, Craggs, & Kumar, 1998). Young infants might also be particularly vulnerable because they depend on their mothers for primary interactions that form the basis of their timely acquisition of developmental skills (Coyl, Roggman, & Newland, 2002). In a nutshell, even young infants of clinically depressed mothers are already different from infants of nondepressed mothers, and they experience an atypical environment and are less likely to have the development of their perceptual and cognitive capacities supported. The existing literature indicates that maternal emotional disposition shapes infants' biology and experience and thus contributes to the development of infants' information-processing skills. Because clinically depressed caregivers provide less general stimulation and less relevant stimulation to their infants than nondepressed caregivers do, infants' learning about environmental stimuli might be impaired. After several months, infants who possess otherwise normal capacities might nonetheless learn less about the world around them than they would have had their principal caregiver not been depressed (Kaplan et al., 2002).

The nature of maternal depression (e.g., its duration and severity), the particular infant developmental outcomes assessed (e.g., motor skills, perception, cognition, or language), and the context with respect to other risk and protective factors (e.g., maternal education, socioeconomic status) have all been suggested as important moderators of the effects of postnatal maternal depression on infant development. Here, we found that infants of nondepressed mothers discriminated variation in object perspective, whereas infants of clinically depressed mothers did not, controlling for stimulus exposure as well as a variety of sociodemographic characteristics in the groups.

The incidence of perinatal depression varies with the population surveyed, but estimated rates for depression among pregnant and postpartum women range from 5% to 25% (O'Hara & Swain, 1996). Each year more than 400,000 infants are born to mothers who are depressed, and perinatal depression is the most underdiagnosed obstetric complication in the United States. Besides its deleterious effects on women and mothers, maternal depression has been termed "a global threat" to children's health, development, and behavior (Wachs, Black, & Engle, 2009). Infants of clinically depressed mothers have previously been reported to manifest diminished sensitivity to social stimuli, and children of clinically depressed mothers deficits in attention and cognition. The present study suggests that such effects are not domain specific or late developing, but may represent a more generalized early onset deficit in visual cognition. How extensive or enduring such deficiencies may be are open questions and should compel continuing research.

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