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Discrimination of facial expression by 5-month-old infants of nondepressed and clinically depressed mothers

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ABSTRACT

Five-month-old infants of nondepressed and clinically depressed mothers were habituated to either a face with a neutral expression or the same face with a smile. Infants of nondepressed mothers subsequently discriminated between neutral and smiling facial expressions, whereas infants of clinically depressed mothers failed to make the same discrimination.

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1. Introduction

Facial expressions convey essential social signs that call for immediate and exact recognition. Sensitivity to variations in facial expression is a precursor to decoding and assigning meaning to others' emotions, and so accurate perception, discrimination, and recognition of facial expressions is vital to healthy emotional functioning and appropriate interpersonal interactions (Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001; Reissland & Shepherd, 2006). Human beings are skilled at discriminating facial expressions. Indeed, research indicates that as early as 2–3 months of age infants (of nondepressed mothers) reliably discriminate a range of facial expressions, such as happiness, sadness, anger, fear, and surprise (e.g., Barrera & Maurer, 1981; Bornstein & Arterberry, 2003; Caron, Caron, & Myers, 1985; LaBarbera, Izard, Vietze, & Parisi, 1976; Ludemann, 1991; Serrano, Iglesias, & Loches, 1995; Young-Browne, Rosenfield, & Horowitz, 1977).

As the neurodevelopment of face processing during infancy and childhood shows, these abilities follow a natural history (see Johnson, 2005, for review). Newborn infants preferentially respond to faces generally (Johnson & Morton, 1991; Sugita, 2008), a behavior thought to be mediated by the subcortical visuo-motor pathway that processes low spatial frequency "coarse" information about faces (Mancini et al., 1998; Simion, Valenza, Umiltà, & Dalla Barba, 1998). Abilities to recognize individual faces and make finer discriminations based on internal features of faces develop later and are mediated by the ventral stream of visual cortical processing (de Schonen & Mathivet, 1989) that matures around the second month of life. Thus, the face-sensitive N170 is present from at least 3 months of age (although it has a slightly longer latency in infants than in adults; de Haan, Pascalis, & Johnson, 2002; Halit, de Haan, & Johnson, 2003) but continues to develop into middle childhood as it becomes more specifically tuned (Johnson, 2011).

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As babies improve in their acuity (Held, Birch, & Gwiazda, 1980), the internal features of faces become more prominent (Turati, Cassia, Simion, & Leo, 2006). However, experience too has rapid as well as lasting influences on human visual development (Maurer, Lewis, Brent, & Levin, 1999; Maurer, Mondloch, & Lewis, 2007). Experience in processing faces plays a critical role in establishing a mature face-processing system. Infant monkeys exposed first to either human or monkey faces following deprivation of face exposure entirely, selectively discriminate the exposed species of face and show marked difficulty in regaining the ability to discriminate the other nonexposed species of face (Sugita, 2008). Likewise, human infants are better at recognizing a face if the face is from their own ethnic group than from another ethnic group, an effect that obtains for Africans, Japanese, Koreans, Chinese, East Indians as well as European Americans and African Americans. This effect appears to be the product of experience with faces from various ethnic groups, and its strength depends on amount of exposure to people of different ethnicities (Hancock & Rhodes, 2008; Kelly et al., 2007; Meissner & Brigham, 2001). More germane to the present study, Kuchuk, Vibbert, and Bornstein (1986) examined sensitivity to varying intensities of smiling faces and their experiential correlates in 3-month-olds (of nondepressed mothers). Infants discriminated different levels of smiles, and infants whose mothers more often encouraged their attention to the mothers' own face while she was smiling showed stronger preferences for higher intensities of smiles, suggesting that infants' sensitivity to facial expressions relates to their experiences. de Haan, Belsky, Reid, Volein, and Johnson (2004) investigated the relation between the emotional environment provided by mothers (as indexed by affective measures of their personality) and 7-month-olds' processing of emotional experiences (as indexed by visual attention and event-related potentials). They too found that the emotional environment experienced by infants contributed to the development of infants' sensitivity to facial expressions.

Mothers' facial expressions are typically the first facial expressions that infants experience and the ones they experience in the greatest numbers (Montague & Walker-Andrews, 2002; Nelson, Morse, & Leavitt, 1979). In this respect, infants of depressed mothers have systematically different social experiences than do infants of nondepressed mothers (Field, 1995). Although they show similar levels of gazing at and vocalizing to their infants as nondepressed mothers (Field et al., 2005), depressed mothers tend to smile less and interact with their infants in a withdrawn and muted style (Cohn, Matias, Tronick, Connell, & Lyons-Ruth, 1986; Field et al., 1985; Field, Diego, & Hernandez-Reif, 2009; Field, 1992). Thus, infants and children of clinically depressed mothers experience an atypical emotional environment characterized by disproportionately high levels of exposure to sad, angry, or neutral facial expressions compared to other infants (Dawson et al., 2003).

Depressed mothers also provide their infants with less optimal levels of general stimulation (Field, 1998; Murray, Hipwell, Hooper, Stein, & Cooper, 1996). Mothers with greater depressive symptomatology show lower levels of sensitive-responsiveness in interacting with their infants (NICHD Early Child Care Research Network, 1999). Lovejoy, Graczyk, O'Hare, and Neuman (2000) meta-analyzed 46 studies linking maternal depression with observed mothering and learned that the strongest relations obtain in children under 1 year of age. Infants of depressed mothers are therefore less likely to be exposed to smiling and have their discrimination capacities supported.

For their part, infants typically react negatively and avert their gaze when their mothers are expressionless (still-face) during a face-to-face interaction (Gusella, Muir, & Tronick, 1988; Stack, 2004) and when mothers are instructed to behave as if depressed (Cohn & Tronick, 1983; Manian & Bornstein, 2009). However, infants of depressed mothers exhibit less negative behavior during such still-face interactions (Field, 1984; Pelaez-Nogueras, Field, Hossain, & Pickens, 1996), suggesting that they may be more accustomed to "still-face" expressions in their mothers and so experience less violation of expectancy during such situations. Taken together, these findings suggest the hypothesis that, by 5 months of age, infants of nondepressed mothers will have little difficulty discriminating facial expressions (especially happy), whereas infants of depressed mothers will not make such discriminations. We tested this hypothesis here.

Maternal depression has been implicated in multiple adverse effects on infant perception and behavior. Germane to this study, infants of depressed mothers reportedly experience difficulty processing and discriminating faces and facial expressions (Hernandez-Reif, Field, Diego, Vera, & Pickens, 2006). Hernandez-Reif, Field, Diego, and Largie (2002) observed that infants of depressed mothers require more trials, and take almost twice as long, to habituate to their mother's face and voice as infants of nondepressed mothers and, afterward, in a posthabituation test with the face and voice of their mother and a female stranger, infants of depressed mothers fail to discriminate a novel stranger relative to their mother, whereas infants of nondepressed mothers do so successfully. At 3 months, infants of depressed mothers are reputedly less responsive to facial expressions than infants of nondepressed mothers (Pickens & Field, 1995). Three- to 6-month infants of depressed mothers are less likely to look at facial expressions displayed by either their mother or stranger (Diego et al., 2004). In a facial affect discrimination task, 3-month-olds of nondepressed mothers looked longer at sad facial expressions than infants of depressed mothers (Field, Pickens, Fox, Gonzalez, & Nawrocki, 1998).

The present study attempts to advance the extant literature on face perception in infants of depressed versus nondepressed mothers with the following features. Whereas 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), here we first identified mothers with depressive symptomatology but subsequently selected into the study only those who received a diagnosis of depression as defined by extensive clinical interview. Both a history of maternal depression and greater current maternal depression impact infant development adversely (Kurstjens & Wolke, 2001; NICHD Early Child Care Research Network, 1999; Striano, Brennan, & Vanman, 2002). In most studies of infants of depressed mothers, depression and low SES, both of which independently undermine infant performance, are confounded; here we assessed infants of nondepressed and clinically depressed mothers from middle-SES families. Whereas most studies of face perception use images of infants' own mothers (thereby ceding control over the independent variable), here we used

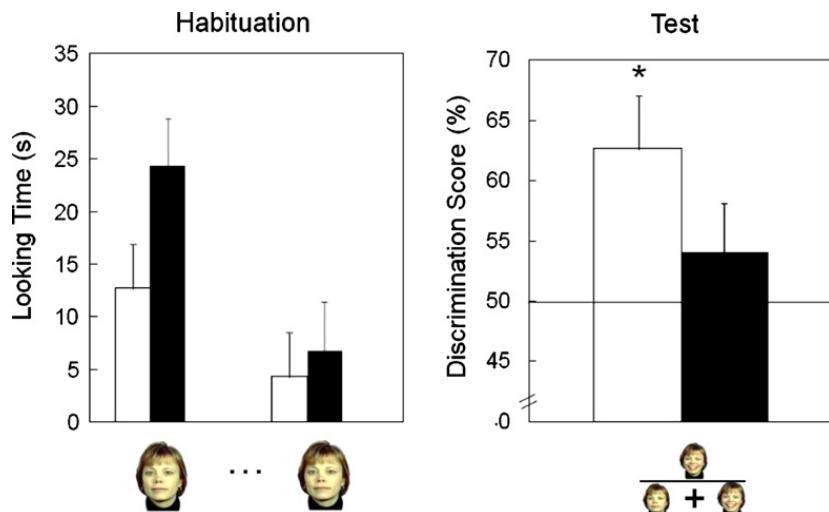


Fig. 1. Habituation (left: baseline and criterion trials) and facial expression discrimination (right: test trials) in infants of nondepressed (□) and clinically depressed (■) mothers. * $p < .05$.

images of faces of people equally unknown to infants. Similarly, many studies of infant face perception use multimodal stimuli—faces and voices. However, infants of depressed mothers are known to orient less well to synchronized sights and sounds (Abrams, Field, Scafidi, & Prodromidis, 1995; Zuckerman, Bauchner, Parker, & Cabral, 1990). Here, we restricted infants to discrimination of faces only. In many studies, infants are only familiarized with stimulus faces they are meant to discriminate; here, we used an infant-control procedure that ensured that each infant habituated to a facial expression before any discrimination test was undertaken. Finally, existing studies have tested relatively easy discriminations between widely different facial expressions (e.g., happy–sad) often of different faces; here, we asked if infants could make finer discriminations of smiling versus neutral expressions of the same face.

2. Methods

2.1. Participants

Twenty-eight 5-month-old infants (M age = 153.6 days, SD = 11.4; 9 girls) participated. The sample was physically healthy and term and 72% European American, 14% Asian American, 7% African American, and 7% Latin American. 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 53.5 (SD = 14.8). 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. Fourteen infants had mothers who were diagnosed as clinically depressed, and 14 infants’ mothers were nondepressed. Experimenters who conducted the laboratory procedures with infants were blind to mothers’ depression status.

2.2. Apparatus

The facial expression stimuli consisted of two color images of two women, one image showing a neutral expression and one a broad toothy smile. Examples are shown in Fig. 1. The stimuli were presented on a 31 cm × 23 cm computer screen. On habituation trials, infants viewed one image, centrally located in a black background. Each face subtended a visual angle of approximately 8.5° by 13.0°. An 8.5° by 8.5° red cross centered against the black background appeared before each trial briefly to re-center the infant’s fixation. The experimenter initiated presentation of each trial after the infant was judged to fixate the cross. An unrelated 10.2° by 13.5° geometric shape that consisted of a red square, yellow circle, and blue triangle against a white background was used to index infants’ prehabituation and posttest attention.

2.3. Procedure

The experiment tested infants' discrimination between a neutral facial expression and a smile of the same person. In an infant-control habituation procedure (Bornstein, 1985), half of the infants were habituated to a face with the neutral expression, and half to the same face with the smile; half of the infants in each group were habituated to one person and half to another person. Following habituation, infants viewed the neutral expression and the smile together in 2 paired-presentation test trials. The left-right positions of the images were reversed between test trials. Infants were seated directly in front of the computer screen at a viewing distance of approximately 36 cm in a dimly lit room.

A video camera, located above the computer screen, captured the infant's face and the light from the computer screen, and its video signal was displayed 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 habituation trials, the experimenter depressed a timing key indicating 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. On test trials, the experimenter pressed different keys corresponding to the left and right sides of the stimulus display. The infant began to accumulate looking time when judged to look at the image for a minimum of 1 s, and to terminate each trial the infant had to look away from the image for a minimum of 2 s; these parameters defined a criterion look. The session began with 1 prehabituation trial. On repeated trials during habituation, infants saw the same woman's face wearing the one expression. The mean duration of the infant's first 2 looks constituted a baseline, and stimulus presentations continued until the infant reached a habituation criterion of 2 consecutive looks averaging less than 50% of the baseline. Infants were therefore required to view a minimum of 4 exposures of the stimulus face during habituation. If infants did not reach the habituation criterion in 16 trials, the habituation phase was terminated ($n = 3$, all in the nondepressed group). Based on the experimenter's button presses, a microprocessor accumulated infant looking time for each trial, calculated the baseline, and determined when the infant met the habituation criterion. Following habituation, infants were presented with 2 test trials of paired images, the neutral expression and the smile. The session ended with 1 posttest trial. To establish inter-observer reliability, a second experimenter judged infant looking independently for approximately 33% of the infants; inter-observer reliability averaged $r = .96$.

3. Results and discussion

Preliminary analyses showed no significant main effects for or interactions with infant gender or face set. Thus, all analyses collapse across these factors.

No differences were found between infants in the maternal clinically depressed and nondepressed groups in number of trials to habituation, $t(26) = 1.29$, ns (M nondepressed = 10.29, $SD = 4.27$; M clinically depressed = 8.43, $SD = 3.28$), or the total amount of looking during habituation, $t(26) = .90$, ns (M nondepressed = 150.59 s, $SD = 88.95$; M clinically depressed = 122.76 s, $SD = 73.83$).

Infants' mean looking times on the baseline and criterion trials of habituation are shown in the left half of Fig. 1. These trials were analyzed in a 2×2 ANOVA with maternal group (nondepressed, clinically depressed) as a between-infants factor and trial (baseline, criterion) as a within-infants factor. The analyses revealed a large main effect for trial, $F(1, 26) = 26.84$, $p < .001$, partial $\eta^2_p = .51$. No other main effects or interactions were significant. The main effect for trial is attributable to more looking on the habituation baseline trials than on the habituation criterion trials. Because the habituation criterion was 50% of the baseline, achieving criterion performance means a significant difference in looking on baseline and criterion trials. It also means that babies habituated. To rule out alternative factors (e.g., fatigue and sensory adaptation) accounting for the decline in attention during habituation, infants' looking to the posttest stimulus (M nondepressed = 7.90 s, $SD = 5.85$; M clinically depressed = 6.58 s, $SD = 5.15$) was compared to their looking to the prehabituation stimulus (M nondepressed = 5.74 s, $SD = 3.92$; M clinically depressed = 9.93 s, $SD = 10.37$) in a 2×2 ANOVA with maternal group (nondepressed, clinically depressed) as a between-infants factor and trial (prehabituation, posttest) as a within-infants factor. The analysis revealed no main effects or interactions, all $Fs < 2.71$, ns.

To test the main hypothesis of the study – whether infants of nondepressed and clinically depressed mothers discriminate between neutral and smiling expressions of the same face – a discrimination score was calculated for each group by dividing infants' total amount of looking to the novel expression in the test by infants' total amount of looking during the test and converting it to a percentage. Mean discrimination scores for each group appear in the right half of Fig. 1. Infants' discrimination scores were compared to chance (50%). Infants of nondepressed mothers showed a mean discrimination score significantly greater than chance, $t(13) = 12.93$, $p < .001$, $d = .87$, whereas the mean discrimination score of infants of clinically depressed mothers did not differ from chance, $t(13) = .98$, ns. Furthermore, the number of infants of nondepressed mothers differed significantly from chance (Sign Test, $p = .029$), whereas the number of infants of clinically depressed mothers whose discrimination scores exceeded chance did not differ from chance (Sign Test, $p = .395$).

Perhaps infants' discrimination of facial expressions is asymmetric; that is, they discriminate smiling from another facial expression (sad), but not that facial expression from smiling (Hernandez-Reif, Field, Diego, & Ruddock, 2006). To compare discrimination scores as a function of habituation expression, t -tests were conducted for each maternal group separately (neutral discriminated from smile; smile discriminated from neutral). No differences in discrimination scores emerged

depending on which face expression infants were habituated to in either the nondepressed or clinically depressed maternal groups.

4. Conclusions

Infants of depressed mothers are known to suffer dysregulation in their biochemistry, physiology, and behavior (Field, 1998; Hart, Field, del Valle, & Pelaez-Nogueras, 1998; Hernandez-Reif, Field, Del Pino, & Diego, 2000; Weinberg & Tronick, 1998), and they are known to have systematically different experiences from infants of nondepressed mothers. Notably, compared to nondepressed mothers, depressed mothers display more flat affect and fewer positive facial expressions toward their infants. This literature indicates that depressed mothers provide their infants with different emotional rearing experiences and infants of depressed mothers perceive, function, and respond differently from infants of nondepressed mothers. Here, we found that 5-month-olds of nondepressed and clinically depressed mothers did not differ in their initial attention to faces or, under an infant-control procedure, in habituating to facial expressions. However, the two groups differed in their fine discrimination of facial expressions, with infants of clinically depressed mothers showing a disadvantage.

Infants of depressed mothers have different social experiences to infants of nondepressed mothers (Field, 1995), and depressed mothers have more withdrawn and intrusive interaction styles (Field, Diego, & Hernandez-Reif, 2009). Infants of depressed mothers are less likely to be exposed to smiling facial expressions, and they do not have their discrimination capacities supported. Even though infants' emotional experiences were not directly studied, based on the extant extensive literature we presumed maternal emotional disposition shapes infants' daily experiences and thus contributes to the development of infants' face processing.

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 and can be expected to affect the comparability of findings across studies as well as account for variation in results observed in the literature concerning the role of maternal depression in child development. Here, we found that infants of nondepressed mothers discriminated fine differences in facial expression, whereas infants of clinically depressed mothers did not, controlling for SES in the groups and for stimulus exposure.

Is the diminished sensitivity of infants of clinically depressed mothers to changes in facial expression specific, or does it represent a more generalized visual deficit? If a general deficit, how extensive or enduring is it? Our next studies are designed to address these questions in infants of clinically depressed mothers.

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References

- Abrams, S., Field, T., Scafidi, F., & Prodromidis, M. (1995). Maternal depression effects on infants' Brazelton Scale performance. *Infant Mental Health Journal*, 16, 231–235.
- Barrera, M. E., & Maurer, D. (1981). The perception of facial expressions by the three-month-old. *Child Development*, 52, 203–206.
- Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for the Beck Depression Inventory* (2nd ed.). San Antonio, TX: The Psychological Corporation.
- Bornstein, M. H. (1985). Habituation as a measure of visual information processing in human infants: Summary, systemization, and synthesis. In G. Gottlieb, & N. Krasnegor (Eds.), *Development of audition and vision during the first year of postnatal life: A methodological overview* (pp. 253–295). Norwood, NJ: Ablex.
- Bornstein, M. H., & Arterberry, M. E. (2003). Recognition, discrimination, and categorization of smiling by 5-month-old infants. *Developmental Science*, 6, 585–599.
- Bornstein, M. H., Hahn, C., Suwalsky, J. T. D., & Haynes, O. M. (2003). Socioeconomic status, parenting, and child development: The four-factor index of social status and the socioeconomic index of occupations. In M. H. Bornstein, & R. H. Bradley (Eds.), *Socioeconomic status, parenting, and child development* (pp. 29–82). Mahwah, NJ: Erlbaum.
- Caron, R. F., Caron, A. J., & Myers, R. S. (1985). Do infants see emotional expressions in static faces? *Child Development*, 56, 1552–1560.
- Cohn, J., & Tronick, E. (1983). Three-month-old infants' reaction to simulated maternal depression. *Child Development*, 54, 185–193.
- Cohn, J. F., Matias, R., Tronick, E. Z., Connell, D., & Lyons-Ruth, K. (1986). Face-to-face interactions of depressed mothers and their infants. In E. Z. Tronick, & T. Field (Eds.), *Maternal depression and infant disturbance* (pp. 31–45). San Francisco: Jossey-Bass.
- Dawson, G., Ashman, S., Pangiotides, H., Hessl, D., Self, J., Yamada, E., et al. (2003). Preschool outcomes of children of depressed mothers: Role of maternal behaviour, contextual risk, and children's brain activity. *Child Development*, 74, 1158–1175.
- de Haan, M., Pascalis, O., & Johnson, M. H. (2002). Specialization of neural mechanisms underlying face recognition in human infants. *Journal of Cognitive Neuroscience*, 14, 199–209.
- de Haan, M., Belsky, J., Reid, V., Volein, A., & Johnson, M. H. (2004). Maternal personality and infants' neural and visual responsivity to facial expressions of emotion. *Journal of Child Psychology and Psychiatry*, 45, 1209–1218.
- de Schonen, S., & Mathivat, E. (1989). First come, first served: A scenario about development of hemispheric specialization in face recognition during infancy. *Current Psychology of Cognition*, 9, 3–44.
- Diego, M. A., Field, T., Jones, N. A., Hernandez-Reif, M., Cullen, C., Schanberg, S., et al. (2004). EEG responses to mock facial expressions by infants of depressed mothers. *Infant Behavior and Development*, 27, 150–162.
- Field, T. M. (1984). Early interactions between infants and their postpartum depressed mothers. *Infant Behavior and Development*, 7, 517–522.

- Field, T. (1992). Infants of depressed mothers. *Development and Psychopathology*, 4, 49–66.
- Field, T. (1995). Infants of depressed mothers. *Infant Behavior and Development*, 18, 1–13.
- Field, T. (1998). Maternal depression effects on infants and early interventions. *Preventive Medicine*, 27, 200–203.
- Field, T., Sandberg, D., Garcia, R., Vega-Lahr, N., Goldstein, S., & Guy, L. (1985). Pregnancy problems, postpartum depression, and early mother–infant interaction. *Developmental Psychology*, 21, 1152–1156.
- Field, T., Pickens, J., Fox, N., 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*, 31, 358–363.
- Field, T., Nadel, J., Hernandez-Reif, M., Diego, M., Vera, Y., Gil, K., et al. (2005). Depressed mothers' infants show less negative affect during non-contingent interactions. *Infant Behavior and Development*, 28, 426–430.
- Field, T., Diego, M., & Hernandez-Reif, M. (2009). Depressed mothers' infants are less responsive to face and voices. *Infant Behavior and Development*, 32, 239–244.
- First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. W. (2001). *User's guide for the Structured Clinical Interview for DSM-IV-TR Axis I disorders—Research version*. New York: Biometrics Research.
- Gusella, J., Muir, D., & Tronick, E. (1988). The effect of manipulating maternal behavior during an interaction on three-and six-month-olds' affect and attention. *Child Development*, 59, 1111–1124.
- Halit, H., de Haan, M., & Johnson, M. H. (2003). Cortical specialization for face processing: Face-sensitive event-related potential components in 3 and 12 month-old infants. *NeuroImage*, 19, 1180–1193.
- Hancock, K. J., & Rhodes, G. (2008). Contact, configural coding and the other-race effect in face recognition. *British Journal of Psychology*, 99, 45–56.
- Hart, S., Field, T., del Valle, C., & Pelaez-Nogueras, M. (1998). Depressed mothers' interactions with their one-year-old infant. *Infant Behavior and Development*, 21, 519–525.
- Held, R., Birch, E., & Gwiazda, J. (1980). Stereoaucuity in human infants. *Proceedings of the National Academy of Sciences of the United States of America*, 77, 5572–5574.
- Hernandez-Reif, M., Field, T., Del Pino, N., & Diego, M. (2000). Less exploring by mouth occurs in newborns of depressed mothers. *Infant Mental Health Journal*, 21, 204–210.
- Hernandez-Reif, M., Field, T., Diego, M., & Largie, S. (2002). Depressed mothers' newborns show longer habituation and fail to show face/voice preference. *Infant Mental Health Journal*, 23, 643–653.
- Hernandez-Reif, M., Field, T., Diego, & Ruddock, M. (2006). Greater arousal and less attentiveness to face/voice stimuli by neonates of depressed mothers on the Brazelton Neonatal Behavioral Assessment Scale. *Infant Behavior and Development*, 29, 594–598.
- Hernandez-Reif, M., Field, T., Diego, M., Vera, Y., & Pickens, J. (2006). Happy faces are habituated more slowly by infants of depressed mothers. *Infant Behavior and Development*, 29, 131–135.
- Hollingshead, A. B. (1975). *Four factor index of social status*. Unpublished manuscript. New Haven, CT: Department of Sociology, Yale University.
- Jaffe, J., Beebe, B., Feldstein, D., Crown, C., & Jasnow, M. (2001). Rhythms of dialogue in infancy: Coordinated timing in development. *Monographs of the Society for Research in Child Development*, 66, vii–132.
- Johnson, M. H. (2005). Subcortical face processing. *Nature Reviews Neuroscience*, 6, 766–774.
- Johnson, M. H. (2011). Developmental neuroscience, psychophysiology, and genetics. In M. H. Bornstein, & M. E. Lamb (Eds.), *Developmental science: An advanced textbook* (6th ed., pp. 199–237). Routledge/New York: Psychology Press/Taylor & Francis.
- Johnson, M. H., & Morton, J. (1991). *Biology and cognitive development: The case of face recognition*. Oxford, UK: Blackwell.
- Kelly, D. J., Quinn, P. C., Slater, A. M., Lee, K., Ge, L., & Pascalis, O. (2007). The other-race effect develops during infancy: Evidence of perceptual narrowing. *Psychological Science*, 8, 1084–1089.
- Kuchuk, A., Vibbert, M., & Bornstein, M. H. (1986). The perception of smiling and its experiential correlates in three-month-old infants. *Child Development*, 57, 1054–1061.
- Kurstjens, S., & Wolke, D. (2001). Effects of maternal depression on cognitive development of children over the first 7 years of life. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 42, 623–636.
- LaBarbera, J. D., Izard, C. E., Viette, P., & Parisi, S. A. (1976). Four- and six-month-old infants' visual responses to joy, anger, and neutral expressions. *Child Development*, 47, 535–538.
- Lovejoy, M. C., Graczyk, P., O'Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior: A meta-analytic review. *Clinical Psychology Review*, 20, 561–592.
- Ludemann, P. M. (1991). Generalized discrimination of positive facial expressions by seven- and ten-month-old infants. *Child Development*, 62, 55–67.
- Mancini, J., Casse-Perrot, C., Giusiano, B., Girard, N., Camps, R., Deruelle, C., et al. (1998). Face processing development after a perinatal unilateral brain lesion. *Human Frontiers Science Foundation Developmental Cognitive Neuroscience Technical Report Series* (Report No. 98.6).
- Manian, N., & Bornstein, M. H. (2009). Dynamics of emotion in infants of clinically depressed and nondepressed mothers. *Journal of Child Psychology and Psychiatry*, 50, 1410–1418.
- Maurer, D., Lewis, T. L., Brent, H. P., & Levin, A. V. (1999). Rapid improvement in the acuity of infant after visual input. *Science*, 286, 108–110.
- Maurer, D., Mondloch, C. J., & Lewis, T. L. (2007). Sleeper effects. *Developmental Science*, 10, 40–47.
- Meissner, C., & Brigham, J. (2001). Thirty years of investigating the own-race bias in memory for faces. *Psychology, Public Policy, and Law*, 7, 3–35.
- Montague, D., & Walker-Andrews, A. (2002). Mothers, fathers and infants: The role of person familiarity and parental involvement in infants' perception of emotion expressions. *Child Development*, 73, 1339–1352.
- Murray, L., Hipwell, A., Hooper, R., Stein, A., & Cooper, P. (1996). The cognitive development of 5-year-old children of postnatally depressed mothers. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 37, 927–935.
- Nelson, C., Morse, P., & Leavitt, L. (1979). Recognition of facial expressions by seven-month-old infants. *Child Development*, 50, 1239–1242.
- NICHD [Early Child Care Research Network]. (1999). Chronicity of maternal depressive symptoms, maternal sensitivity and child functioning at 36 months: Results from the NICHD Study of Early Child Care. *Developmental Psychology*, 35, 1297–1310.
- Pelaez-Nogueras, M., Field, T., Hossain, Z., & Pickens, J. (1996). Depressed mothers' touching increases infants' positive affect and attention in still-face interactions. *Child Development*, 67, 1780–1792.
- Pickens, J., & Field, T. (1995). Facial expressions and vagal tone in infants of depressed and non-depressed mothers. *Early Development and Parenting*, 4, 83–89.
- Reissland, N., & Shepherd, J. (2006). The effect of maternal depressed mood on infant emotional reaction in a surprise-eliciting situation. *Infant Mental Health Journal*, 27, 173–187.
- Serrano, J. M., Iglesias, J., & Loeches, A. (1995). Infants' responses to adult static facial expressions. *Infant Behavior and Development*, 18, 477–482.
- Simion, F., Valenza, E., Umiltà, C., & Dalla Barba, B. (1998). Preferential orienting to faces in newborns: A temporal-nasal asymmetry. *Journal of Experimental Psychology—Human Perception and Performance*, 24, 1399–1405.
- Stack, D. (2004). Touching during mother–infant interactions. In T. Field (Ed.), *Touch and massage in early child development* (pp. 41–81). Johnson & Johnson Pediatric Institute.
- Steer, R. A., & Beck, A. T. (2000). The Beck Depression Inventory-II. In W. E. Craighead, & C. B. Nemeroff (Eds.), *The Corsini encyclopedia of psychology and behavioral science* (3rd ed., vol. 1, pp. 178–179). New York: Wiley.
- Striano, T., Brennan, P. A., & Vanman, E. J. (2002). Maternal depressive symptoms and 6-month-old infants' sensitivity to facial expressions. *Infancy*, 3, 115–126.

- Sugita, Y. (2008). Face perception in monkeys reared with no exposure to faces. *Proceedings of the National Academy of Sciences of the United States of America*, 105, 394–398.
- Turati, C., Cassia, V. M., Simion, F., & Leo, I. (2006). Newborns' face recognition: Role of inner and outer facial features. *Child Development*, 77, 297–311.
- Weinberg, M. K., & Tronick, E. Z. (1998). The impact of maternal psychiatric illness on infant development. *Journal of Clinical Psychiatry*, 59, 53–61.
- Young-Browne, G., Rosenfield, H. M., & Horowitz, F. D. (1977). Infant discrimination of facial expressions. *Child Development*, 49, 555–562.
- Zuckerman, B., Bauchner, H., Parker, S., & Cabral, H. (1990). Maternal depressive symptoms during pregnancy and newborn irritability. *Journal of Development and Behavioral Pediatrics*, 11, 190–194.