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Maternal Sensitivity and the Learning-Promoting Effects of Depressed and Non-Depressed Mothers' Infant-Directed Speech

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Abstract

The hypothesis that aspects of current mother-infant interactions predict an infant's response to maternal infant-directed speech (IDS) was tested. Relative to infants of non-depressed mothers, those of depressed mothers acquired weaker voice-face associations in response to their own mothers' IDS in a conditioned-attention paradigm, although this was partially attributable to demographic differences between the two groups. The extent of fundamental frequency modulation (ΔF_0) in maternal IDS was smaller for infants of depressed than non-depressed mothers, but did not predict infant learning. However, Emotional Availability Scale ratings of maternal sensitivity, coded from videotapes of mothers and infants engaged in a brief play interaction, were significant predictors of infant learning, even after maternal depression, its demographic correlates, and antidepressant medication use had been taken into account. These findings are consistent with a role for experience-dependent processes in determining IDS's effects on infant learning.

Keywords

Maternal sensitivity; postpartum depression; infant learning; IDS; conditioned-attention paradigm

Postpartum depression occurs in about 13% of new mothers (O'Hara, Neunaber & Zekoski, 1984) and is associated reduced sensitivity, synchrony, and reciprocity during interactions with infants (Cohn, Campbell, Matias, & Hopkins, 1990; Field, Healy, Goldstein, & Guthertz, 1990), as well as elevated risk for later problems in cognitive and socio-emotional development (Cicchetti, Rogosch, & Toth, 2002; Murray, Fiori-Cowley, Hooper, & Cooper, 1996, Teti, Gelfand, Messinger, & Isabella, 1995). Indeed, many of the effects of caregiver depression on child development appear to be mediated by maternal insensitivity and relatively lower quality infant-directed stimulation (Murray, 1992; Teti et al., 1995).

One type of maternal stimulation affected by depression is infant-directed speech (IDS). Caregivers normally exaggerate prosodic cues and otherwise simplify their speech towards infants (Jacobsen, Boersma, Fields, & Olson, 1983; Snow, 1972), but depressed mothers' IDS has relatively lower pitch modulation (Bettes, 1988; Kaplan, Bachorowski, Smoski, & Zinser, 2001; Zlochower & Cohn, 1996). A series of experiments using a conditioned-attention paradigm (reviewed below) has shown that, although IDS normally serves as a "priming" stimulus to facilitate infant associative learning (Kaplan, Jung, Ryther, & Kirk, 1996), IDS produced by depressed mothers is relatively ineffective (Kaplan, Bachorowski, & Zarlengo-Strouse, 1999). Moreover, although 4-month-old infants of depressed mothers learn well in response to IDS produced by unfamiliar non-depressed mothers, older infants of more chronically depressed mothers show poor learning in response to IDS produced by non-depressed as well as depressed mothers (Kaplan, Dungan, & Zinser, 2004), suggesting an experience-based change in responsiveness to maternal IDS. The purpose of the current study was to test the hypothesis that one aspect mother-infant interactions, maternal

sensitivity, contributes to the link between depressed mothers' IDS and poor infant learning in a conditioned-attention paradigm.

The conditioned-attention paradigm is based on the finding that, just as with more traditional "overt" behaviors, attentional responses can be conditioned (Lubow, 1989). That is, attentional responses are maintained or even increase when one stimulus, S1, reliably predicts another, S2. When S1 occurs in isolation, attentional responses diminish, and S1 becomes a less effective signaling stimulus when subsequently followed by reinforcement ("latent inhibition"). With appropriate pairing arrangements and control conditions, attentional responses can be used to infer the formation of stimulus-stimulus associations.

Kaplan, Fox, and Huckeby (1992) applied a conditioned-attention paradigm to the study of association learning in 4-month-old infants. In the pairing phase (3 m), infants in the forward pairing arrangement were given a series of 6 non-overlapping pairings of first a 10-s tone and then a 10-s photographic slide of a smiling face. Infants in separate control conditions were given backward pairings of the face and voice, random presentations of the two, or experienced only the face. In the summation test phase (70 s), which followed immediately, all infants were given 4 10-s presentations of a novel 4×4 checkerboard pattern, a stimulus designed to elicit a low baseline of looking. The tone from the pairing phase was tested for its ability to increase looking at the checkerboard pattern through simultaneous presentations on the first and fourth (or the second and third) checkerboards only. Results showed that the tone acquired the ability to significantly increase looking at the checkerboard ("positive summation") only in the forward pairing condition. This effect was attributed to the formation of S1 (tone)-S2 (face) associations.

This paradigm was used to test the hypothesis that IDS is more effective than ADS at promoting infant learning. Given the greater response-eliciting and arousal-increasing properties of IDS relative to ADS (Kaplan, Goldstein, Huckeby, Owren, & Cooper, 1995), it was predicted that stimuli that soon followed IDS presentation should be learned about better than those that soon followed ADS presentation. This prediction was confirmed by Kaplan et al. (1996). Groups of 4-month-old infants were given 10-s presentations of recorded IDS or ADS segments, rather than a tone, in forward or backward pairing arrangements with a smiling face. Only forward pairings of IDS and the face produced positive summation in the post-conditioning tests.

However, subsequent work with 4-month-old infants of non-depressed mothers showed that although again forward parings of an unfamiliar non-depressed mother's IDS with a smiling face yielded evidence of significant voice-face associative learning, forward pairings of an unfamiliar depressed mother's IDS and a smiling face did not (Kaplan et al., 1999), The extent of fundamental frequency (F_0) modulation (F_0 max-ΔF_0 min, or ΔF_0) in the maternal IDS stimuli was significantly correlated with the mean infant learning score for groups of infants of non-depressed mothers who were tested with those stimuli. In a follow-up study, 4-month-old infants of clinically depressed mothers similarly did not acquire associations when their own or an unfamiliar depressed mother's IDS signaled a face, but showed significant learning when an unfamiliar non-depressed mother's IDS served as signal (Kaplan, Bachorowski, Smoski, & Hudenko, 2002).

Taken together, these studies were consistent with a the idea that learning failures were "in the stimulus," rather than "in the infant," because infants of depressed mothers had the ability to acquire voice-face associations when tested with "high-quality" IDS produced by a non-depressed mother. However, older infants (5- to 13-month-olds) of more chronically depressed mothers not only failed to acquire associations in response to their own mothers' IDS but, in contrast to the 4-month-olds, on average also failed to acquire associations in

response to IDS produced by unfamiliar non-depressed mothers (Kaplan et al., 2004; Exp. 1). The strength of the voice-face association that was acquired in response to non-depressed mothers' stimulation by infants of depressed mothers was inversely proportional to the post-partum duration of the infant's mother's current depressive episode. This finding suggested an acquired decrement in responding to "high-quality" maternal IDS as a consequence of prolonged exposure to a depressed primary caregiver, a result that could not be attributed to low perceptual salience of the IDS or an infant's prior learning that affectively flat IDS does not "go with" a smiling face. Rather, it suggested that something may have changed *about the infant*.

A limit to this apparent generalization was found in an experiment in which 6- to 13-month-old infants of depressed mothers showed significant voice-face associative learning in response to IDS produced by an unfamiliar non-depressed father (Kaplan et al., 2004; Exp. 2). In fact, their learning in response to the non-depressed father's IDS exceeded that observed in a group of infants of non-depressed mothers, who themselves exhibited significant learning.

These findings raise the possibility that an infant's prior experience with a depressed primary caregiver affects the infant's responsiveness to maternal IDS. Kaplan et al. (2004) hypothesized that infants of mothers who are withdrawn and low in sensitivity and contingent responding might, through a process akin to latent inhibition (Lubow, 1989) or learned irrelevance (Linden, Savage, & Overmeier, 1996), learn that their mothers' IDS does not predict reinforcing events in general, or smiling faces in particular. Such learning might eventually be generalized to other female, but not to male, voices. Importantly, learning processes like these may suggest a mechanism through which disordered mother-infant interactions eventually result in deficits in infant attention and learning. The latent inhibition/learned irrelevance hypothesis is consistent with the larger literature on postpartum depression, which shows mediating or moderating effects of maternal sensitivity and responsiveness on child development (Hay, 1997; Milgrom, Westley, & Gemmill, 2004; Murray et al., 1993; Murray & Cooper, 1996).

If a history of interactions in which maternal cues (e.g., IDS) are uncorrelated with reinforcing events reduces the "associability" of those maternal cues, then infant learning in response maternal stimulation should be predicted by measures that capture the quality of mother-infant interactions. In the current experiment, we assessed the quality of mother-infant interactions in a laboratory-based, free-play session using the Emotional Availability Scales (EAS; Emde, 1980; Emde & Easterbrooks, 1985). We predicted that IDS produced by mothers who were low in emotional availability, particularly maternal sensitivity, should less effectively promote infant associative learning in comparison with IDS produced by mothers who were higher in emotional availability. Moreover, maternal sensitivity should be more important than maternal depression diagnosis per se in predicting infant learning in response to maternal IDS.

Method

Participants

Fifty-five mothers and their 5.5- to 13-month-old infants (range: 160-395 days; *M* = 293 days, *SD* = 70.3) were recruited from advertisements in *Colorado Parent*, a local magazine available at no cost at grocery stores and infant-oriented retail stores. The advertisement indicated that all mothers were invited to participate, but that mothers with a history of depression were of particular interest. The mean age of the mothers was 29.5 years (*SD* = 5.5), mean education level was 5.7 (*SD* = 1.8; where 5.0 = earned an associate's degree and 6.0 = earned a bachelor's degree), and mean number of children was 1.6 (*SD* = 0.8). The

mothers' ethnic self-identifications were 29 white (52.7%), 14 Latina (25.5%), 7 African-American (12.7%), 3 Asian (5.4%) and 2 Native American (3.6%). Thirty-one of the infants were girls (56.4%) and 24 were boys (43.6%).

Apparatus

During conditioned-attention tests, infants were placed in a standard car seat situated in front of a large wooden board that had been painted flat black. A 4-inch square translucent Plexiglas projection screen was embedded in the board at approximately infant eye level. Located 1.9 cm to the infant's left of the projection screen was an aperture through which a low-light video camera imaged the infant's face. Two full-face views of the infant were watched by independent observers in separate rooms on 48.3-cm video monitors. Auditory stimuli were presented to infants using a SONY TCM 5000EV tape player. To make sure that looking at the projection screen was not an artifact of infants' visual orienting toward the speaker, it was situated 10 cm below and 33.5 cm behind the infant's head. The distance from the infant's head to the projection screen was, depending on the infant's position in the car seat, approximately 42 cm. Visual stimuli, an achromatic slide of a smiling adult female face and an achromatic 4 × 4 checkerboard pattern, were presented using two computer-controlled slide projectors outfitted with shutters. The checks in the checkerboard pattern each subtended 3° of visual angle. Videotapes of play interactions were made using a SONY CCD-TRV128 Hi-8 camcorder.

Procedure

Mothers were asked first to read and sign informed consent statements for infant testing, audio- and video-taping, and the structured clinical interview. Next, the mother was audio taped in the same room for 3 minutes to elicit "pet the gorilla" utterances (details of all procedures are presented below). This was followed immediately by the 10-min EAS mother-infant videotaping session in a separate play room. During this interval, an experimenter edited the IDS segment in the computer room. Following the EAS taping, the infant conditioned-attention test was carried out in the testing room. Then, mothers filled out questionnaires in the office. Finally, the clinical interview was conducted in the office.

Audio recording—Speech samples were obtained from mothers in a 3-minute play interaction. Mothers were asked to talk to their infants as they would at home. Following 2 minutes, mothers were handed a stuffed toy gorilla and asked to interest their infant in it using the phrase "pet the gorilla." Mothers were instructed to both "ask" and "tell" their infants to "pet the gorilla" to make sure that both declarative and interrogative utterances would be made. This phase of the recording lasted approximately 1 minute. To construct a 10-s IDS segment with roughly the same linguistic content across mothers, we edited out of the speech stream the first two interrogative and the first declarative "pet the gorilla" utterances and repeated them once (e.g., Will you pet the gorilla? Can you pet the gorilla? Pet the gorilla. Will you pet the gorilla? Can you pet the gorilla? Pet the gorilla."). During this phase, the individual responsible for recording and editing the tapes was unaware of maternal self-reports of depression and the interviewer's DSM-IV diagnosis.

Emotional Availability Scales—The quality of current mother-infant interactions was assessed using the Emotional Availability Scales (EAS; Emde, 1980; Emde & Easterbrooks, 1985). After the audiotaping was complete, the dyad was given a basket of attractive, age-appropriate toys and told by the examiner, "Now you can just play together for a few minutes and I will come back in when the next activity is ready." Then, free-play interactions were videotaped through a 1-way mirror for 10 minutes. Later, coders, who had been neither present for nor had any knowledge of the conditioned-attention test, and who were blind with respect to maternal diagnosis, rated the videotapes on 3 scales that assessed

the parent's behavior, Parental Sensitivity, Parental Covert and Overt Hostility, and *Parental Structuring/Non-Intrusiveness*, and 2 scales that assessed the child's behavior, *Child Responsiveness to Parental Bids* and *Child Involvement of Parent in Play*.

Emotional availability is a dyadic construct that assesses both the parent and child's ability to decipher and respond to the other's emotional states and cues. Detailed published criteria were used for scoring the EAS (Biringen, Robinson, & Emde, 2000). These scales use a relational coding approach in which the scoring of one dyadic member's target behavior is determined with consideration to the other's behavior (Ziv, Aviezer, Motti, Sagi, & Koren-Karie, 2000). *Parental Sensitivity* (10-pt. scale; higher scores = greater sensitivity) refers to the parent's responsiveness to the child, her ability to pick up on infant cues, to be warm and soothing during distress, to find stimulating and creative ways to play, and to have high-quality affective exchanges with the child. *Parental Covert and Overt Hostility* (5-pt. scale) involves a parent showing overt or covert discontent, impatience, or anger. *Parental Structuring/Non-Intrusiveness* (9-pt. scale) assesses the extent to which the parent provides an appropriate balance between parent- and child-directed activities, sets the child up for success, and provides "emotional containment" when necessary, but without intrusiveness, over-stimulation or being overly controlling. Lower scores on the *Structuring/Non-Intrusiveness* scale indicate low structuring, a score of 5 indicates optimal structuring, and higher scores indicate overly structuring/intrusive. *Child Responsiveness to Parental Bids* (9-pt. scale) reflects the extent to which the child is eager and willing to engage the parent following a parental bid, and the degree of pleasure displayed by the child in the interaction. *Child Involvement of Parent in Play* (9-pt. scale) reflects the extent to which the child attends to and engages the parent in play.

Coders, graduate students in clinical psychology, were trained by an expert in parent-child relationships with extensive experience in performing, coding, and interpreted the EASs (fourth author). Reliability videotapes and training manuals, with extensive behavioral descriptors for the scale points, were used to train observers to a reliability of .70 or greater with the trainer on three consecutive tapes of lab visits. Intra-class correlations coefficients calculated for 16 of the 55 EAS participants (32%) were .93 for *Parental Sensitivity*, .69 for *Parental Structuring/Non-intrusiveness*, .96 for Parental *Covert and Overt Hostility*, .85 for *Child Responsiveness to Parental Bids*, and .61 for *Child Involvement of the Parent in Play*.

The reliability and validity of the EAS has been established in many studies (Biringen et al., 2000; Easterbrooks, Biesecker, & Lyons-Ruth, 2000). Inter-observer reliabilities (% agreement as well as kappas) are typically above .80. Test-retest reliability is high through the child's second year of life (Biringen et al., 2000). The EAS exhibits significant cross-context reliability and continuity (Bornstein et al., 2006). Convergent validity has been established through significant correlations between EAS scales and attachment classification from Strange Situation and maternal ratings via Attachment Q-sorts (Ziv, et al., 2000).

Conditioned attention tests—On conditioning trials, each infant first heard a 10-s "pet the gorilla" speech segment when the projection screen was uniformly illuminated. At the offset of the speech segment, the infant received a 10-s presentation of a black-and-white photographic slide of a smiling adult female face. A 10-s inter-stimulus interval (ISI), during which the projection screen was uniformly illuminated and only background noise was heard, immediately followed the offset of the face. Infants received six speech segment-face pairings. Ten s after the offset of the sixth face, the post-conditioning test phase began. Infants received 4 10-s presentations of a 4 × 4 black-and-white checkerboard pattern (10-s ISIs). The speech segment from the pairing phase was presented simultaneously with the first and fourth checkerboards, whereas the second and third checkerboards occurred with

only background noise (measured near the infant's head at 58 dB). Durations of infant looking at the projection screen during the 10-s speech segment, face, and checkerboard trials were recorded. Looking was signaled by 2 independent observers when the reflection of the visual stimulus was centered on the infant's pupils. A second observer was present for all tests, with a mean interobserver correlation of .95 (*SD* = .05).

Clinical diagnoses—Mothers were administered the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) and the Structured Clinical Interview for DSM-IV diagnosis (SCID; First, Spitzer, Gibbon, & Williams, 1997). Clinical diagnoses were made by Ph.D.-supervised clinical psychology graduate students with extensive training on the SCID and DSM-IV diagnosis. Training involved intensive coursework, video demonstrations, observation of the trainer by the student, and practice interviews. Interviews lasted about 1 hr. Inter-rater reliability for diagnoses of Major Depression, calculated between the primary rater and a Ph.D.-level second rater yielded a kappa value of .84. Final diagnoses were based on the primary rater. Mothers also filled out the BDI-II and the Denver Maternal Stress, Behavior, and Personal Support Questionnaire, which provided self-reports about a number of demographic variables. In all statistical analyses, "depressed" refers to a DSM-IV Axis-I depression-spectrum diagnosis.

Results

Demographic and Diagnostic Information

Table 1 presents demographic and diagnostic information for depressed and non-depressed mothers and their infants. Of the 18 mothers diagnosed with a depression-spectrum disorder (hereafter referred to as "depressed"), 14 were diagnosed with Major Depressive Disorder (MDD), 3 were diagnosed with Depressive Disorder Not Otherwise Specified (DDNOS), and 1 was diagnosed with Bipolar 1 Disorder (BP1; currently in a depressed episode). One of the mothers diagnosed with MDD was also diagnosed with Dysthymia, resulting in a diagnosis of Double Depression. The relatively high rate of clinical depression in this community sample (30.9%) is likely due to the stated preference for depressed mothers in our recruitment advertisement, and is consistent with our prior studies (Kaplan et al., 2004).

Depressed and non-depressed mothers differed significantly in years of education, $F(1, 53) = 5.62$, $p = .02$, $\eta^2 = .10$, the proportion who were married (50.0% vs. 83.8%, Fisher's exact test, $p = .001$), and the proportion who identified themselves as belonging to an ethnic minority group (72.2% vs. 35.1%, Fisher's exact test, $p = .01$). Depressed and non-depressed mothers did not differ significantly in age, family income, number of children, or the ages of their infants. Depressed mothers had significantly higher BDI-II scores than controls, *M*s = 26.2 vs. 8.4; $F(1, 53) = 57.55$, $p = .001$, $\eta^2 = .52$.

Infant Associative Learning

Infant associative learning data were unavailable for 10 of 55 infants (18.2%) due to excessive fussing, including 3 infants of depressed and 7 infants of non-depressed mothers. For the remaining 45, there was a significant difference between depressed and non-depressed mothers in ethnic minority group status (64.5% vs. 28.6%; Fisher's exact test, $p = .05$), percent married (50.0% vs. 83.9%; Fisher exact test, $p = .03$), and a marginally significant difference in maternal education, $F(1, 43) = 2.86$, $p = .07$.

Pairing phase—Mean looking times at the uniformly illuminated projection screen during the first and last presentations of the IDS segment (voice) and the face are presented in Table 2. A 2 (maternal diagnosis) × 6 (pairing trials) ANOVA using Greenhouse-Geisser corrected degrees of freedom showed no significant effect on looking times during voice

presentations of maternal diagnosis, $F(1, 43) = 0.57$, trials, $F(4, 177) = 0.86$, or their interaction, $F(4, 177) = 1.33$, $p = 1.07$, *n.s*. These data are consistent with all prior infant conditioned-attention studies which have yielded evidence of associative learning only in the summation test phase (Kaplan et al., 1992;1996;1999;2004). They also demonstrate comparable response levels during speech segment presentations for infants of depressed versus non-depressed mothers.

Similarly, a 2 (maternal diagnosis) × 6 (pairing trials) ANOVA with the Greenhouse-Geisser corrected degrees of freedom showed no significant effect on looking during face presentations of maternal diagnosis, $F(1, 43) = 0.08$, trials, $F(4, 159) = 0.72$, or their interaction, $F(4, 159) = 0.67$. These data show that responding to the face reinforcer was comparable for infants of depressed and non-depressed mothers, with no significant decreases in responding across the 6 pairing trials.

Summation test phase—The mean looking times during checkerboard patterns on the four test trials are presented in Table 2 along with the resulting mean difference scores. A mixed 2-factor ANOVA with Greenhouse-Geisser corrected degrees of freedom showed no effect on looking times of diagnosis, $F(1, 43) = 0.13$, a significant effect of trials, $F(3, 135) = 8.42$, $p = .001$, and no significant diagnosis x trials interaction, $F(3, 135) = 0.98$, *n.s*.

Difference scores were calculated by subtracting the mean duration of looking on checkerboard-alone test trials (trials 8 & 9) from that on checkerboard-plus-speech segment test trials (trials 7 & 10). Positive scores indicate that speech segments increased looking at checkerboards, and were interpreted to reveal the formation of voice-face associations, because much previous research has shown that this effect occurs only in forward-pairing arrangements and not standard control conditions (Kaplan et al., 2004). Mean difference scores were higher for infants of non-depressed in comparison to depressed mothers, $F(1, 43) = 4.57$, $p = .05$, $\eta^2 = .10$. An analysis of covariance with infant age as a covariate showed no significant effect of infant age $F(1, 42) = 0.07$, but the effect of maternal depression was still significant, $F(1, 42) = 4.54$, $p = .05$, $\eta^2 = .10$.

Maternal Speech Acoustics

Mean ΔF_0 (max F_0 - min F_0) for depressed mothers' 3 "pet the gorilla" utterances were significantly lower than that for non-depressed mothers, *M*s = 160 Hz vs. 205 Hz, $F(1, 53) = 5.00$, $p = .03$, $\eta^2 = .09$ (for "gorilla" portions of the utterances, *M*s = 121 Hz vs.157 Hz, $F(1, 53) = 3.49$, $p = .07$). However, neither F_0-related measure correlated significantly with infant learning scores, with the higher correlation between difference scores and ΔF_0 in "gorilla" utterances, $r = -.09$, $p = .56$. Infant age did not correlate significantly with ΔF_0 for "gorilla" or "pet the gorilla" utterances, $r = -.05$, and $r = -.24$, $p = .13$, respectively.

Emotional Availability Scales

Mean EAS ratings for each of the 5 subscales were analyzed as a function of maternal diagnosis. In comparison to non-depressed controls, depressed mothers were rated as significantly lower on the *Parental Sensitivity* scale, *M*s = 7.6 vs. 6.8; $F(1, 53) = 7.26$, $p = .01$, $\eta^2 = .12$, and significantly higher on the *Parental Covert and Overt Hostility* scale, *M*s = 1.0 vs. 1.2; $F(1, 53) = 4.46$, $p = .04$, $\eta^2 = .08$. In comparison to infants of non-depressed mothers, infants of depressed mothers were rated as significantly lower on the *Child Responsiveness to Parental Bids* scale, *M*s = 5.6 vs. 6.3, $F(1, 53) = 7.37$, $p = .01$, $\eta^2 = .12$.

Table 3 shows the correlations among EAS subscales and relevant demographic and diagnostic variables. Family income was positively correlated with Parental Sensitivity, Child Responsiveness to Parental Bids, and *Child Involvement of the Parent in Play*, and

significantly negatively correlated with Parental Structuring/Non-intrusiveness, Parental Covert and Overt Hostility. Hostility was also significantly negatively correlated with maternal education, and was higher in unmarried mothers.

Within the EASs, *Parental Sensitivity* was significantly correlated with *Child Responsiveness* and *Child Involvement of the Parent*, and significantly negatively correlated with Parental Covert and Overt Hostility. Parental Structuring/Non-intrusiveness was significantly negatively correlated with *Child Responsiveness to Parental Bids*, and *Child Involvement of the Parent in Play*, and *Child Involvement of the Parent in Play* and *Child Responsiveness to Parental Bids* significantly correlated with each other.

Only *Parental Sensitivity* correlated significantly with infant learning scores, $r = .35$, $p = .05$. An analysis of infant learning scores using a median split of *Parental Sensitivity* ratings (regardless of maternal depression) yielded a significant effect, low sensitivity, $M = 0.43$ s, $SD = 1.9$ vs. high sensitivity, $M = 1.78$ s, $SD = 2.1$, $F(1, 43) = 5.24$, $p = .03$, $\eta^2 = .11$.

There were significant negative correlations between *Parental Covert and Overt Hostility* and mean ΔF_0 for both “gorilla” and “pet the gorilla” utterances. No other EAS scales were correlated with F_0-related measures.

Depression, Sensitivity, and Infant Learning

To evaluate the relative roles of demographic variables, depression diagnosis, antidepressant medication use, and *Parental Sensitivity* scale ratings as predictors of infant learning in response to the infant’s mother’s IDS, we performed a hierarchical linear regression. A composite rating of demographic risk (0-3) was created in which each subject was given 1 pt for the presence of each of the following: ethnic minority status, mother unmarried, and high school education or less for the mother. In the hierarchical linear regression, this composite variable was entered into the equation in step 1, followed by antidepressant medication use in step 2, maternal depression diagnosis in step 3, and finally maternal sensitivity in step 4. Table 4 shows that demographic risk was positively correlated with maternal depression and negatively correlated with maternal sensitivity. Table 5 shows that neither demographic risk nor antidepressant medication use was linked to significant increments in the proportion of variance accounted for in infant learning scores. After these variables had been taken into account, mothers’ depression diagnosis was associated with a marginally significant increment in R^2. However, after the demographic risk, medication, and depression had been entered into the equation, *Parental Sensitivity* was associated with a significant increment in proportion of variance accounted for in infant learning scores, $\Delta R^2 = .179$, $p = .05$. The same results were obtained when infant age was inserted into the equation in step 2.

Discussion

The hypothesis that aspects of current mother-infant interactions predict an infant’s learning in response to maternal IDS was tested. As in prior studies, depressed mothers produced IDS that led to significantly weaker infant associative learning than that produced by non-depressed mothers, although regression analyses showed that this effect was no longer significant in the current study when demographic correlates of maternal depression and antidepressant medication use were first taken into account. In contrast to prior studies, the extent of F_0 modulation did not predict infant learning, and therefore the infant learning failures cannot be attributed to a lack of expanded F_0 contours in depressed mothers’ IDS. However, blind ratings of mother-infant behavior, obtained using videotapes of mothers and infants engaged in a 10-min free play interaction, showed that depressed mothers were significantly lower in sensitivity and significantly higher in hostility relative to non-depressed controls. Infants of depressed mothers were rated as significantly less responsive

to parental bids for attention relative to infants of non-depressed mothers. Importantly, EAS ratings of maternal sensitivity were significant predictors of infant learning in response to his or her own mother's IDS, even after controlling for maternal depression, its demographic correlates, and antidepressant medication use.

The EAS findings were consistent with those from studies showing that depressed mothers are lower in sensitivity, responsiveness, and contingency relative to non-depressed controls (Campbell, Cohn, & Meyers, 1995; Field et al., 1990; Murray, Kempton, Woolgar, & Hooper, 1993). These findings also confirm studies suggesting that infants of depressed mothers are less responsive to their parents than controls (Field et al., 1990; Murray & Cooper, 1996).

Maternal sensitivity predicted a unique proportion of the variance in infant learning. One potential explanation of this finding is that a history of low parental sensitivity causes a reduction in the learning-promoting effectiveness of IDS. Kaplan et al. (2004), drawing on some basic principles from conditioning theory (Mackintosh, 1974), hypothesized that infants of depressed mothers might acquire stimulus-stimulus associations more slowly in this paradigm both because depressed mothers' IDS lacks perceptual salience at the start of the laboratory session, and because a history of non-reinforced exposure to the mother's voice ("latent inhibition") or prior uncorrelated presentations of her voice and reinforcing social interactions ("specific learned irrelevance") may have lowered the associability of maternal IDS before the laboratory session began. With enough exposure to a non-contingent primary caregiver, and especially with little exposure to other, more contingent interaction partners, infants may generalize from their mother's IDS to that produced by any female ("general learned irrelevance;" Linden et al., 1996).

From this perspective, maternal sensitivity should predict infant learning in this paradigm, as was found. However, in contrast to this view, although ΔF_0 was significantly lower in depressed versus non-depressed mothers' IDS, variations in ΔF_0 did not predict individual infants' learning scores. This discrepancy with prior findings (Kaplan et al., 1999) may be attributable to a number of factors, most notably infant age and the infant's familiarity with the IDS segment they heard. In the prior work, 4-month-old infants of non-depressed mothers were tested with unfamiliar depressed mothers' IDS, and presumably had no basis for responding other than the IDS' unconditioned salience. In contrast, in the current work, 5.5- to 13-month-old infants of depressed and non-depressed mothers who were tested with their own mothers' IDS may also have responded based on acquired significance.

Another potentially relevant factor is that ΔF_0 predicted infant learning when group mean infant learning data were analyzed (Kaplan et al., 1999), but it did not predict infant learning here when individual infants' data were analyzed. The significant link between ΔF_0 and infant learning may have been an artifact of averaging the difference scores. Additional research will be needed to tease apart the roles of infant age, familiarity with the mother who produced the IDS sample, and individual- versus group-level data, before the role of the perceptual salience of IDS in conditioning failure can be fully assessed.

Whatever the role of unconditioned signal salience, the results of the current study are consistent with a role for maternal sensitivity in affecting the ease with which maternal IDS enters into association with the smiling face reinforcer. Similar to the "learned irrelevance" hypothesis, Hay (1997) hypothesized that prolonged exposure to a withdrawn, unresponsive, and non-contingent primary caregiver might "disrupt naturally occurring social processes that entrain and regulate an infant's developing capacity for attention." She identified two processes, diminished awareness of contingencies in the social and non-social environment (DeCasper & Carstens, 1981; Dunham & Dunham, 1990; Stanley, Murray, & Stein, 2004),

and adverse effects of emotional dysregulation on infant information-processing (Lemelin, Tarabulsky, & Provost, 2002; Singer & Fagan, 1992), as plausible mechanisms to account for the elevated risk status.

Past research showing that 5.5- to 13-month-old infants of depressed mothers do not exhibit significant learning when "high-quality" IDS produced by an unfamiliar non-depressed mother signals a smiling face (Kaplan et al., 2002; Kaplan et al., 2004) could be consistent with Hay's hypothesized loss of capacity or general disruption of learning by negative affect. However, the strong learning exhibited by infants of chronically depressed mothers in response to an unfamiliar non-depressed father's IDS, coupled with their differential responding to forward versus backward pairings of male IDS and a face (Kaplan et al., 2004), leaves no doubt that these infants can detect stimulus-stimulus contingencies. In the current study there was no evidence of greater fussiness in infants of depressed relative to non-depressed mothers, and subject attrition was comparable for the two groups (17.6% vs. 18.4%).

Thus, at least with respect to infant conditioned-attention data and, in subtle contrast to Hay (1997), we argue that it is precisely because infants of depressed mothers are able to accurately detect stimulus-stimulus contingencies and non-contingencies (Tarabulsky et al, 1996) that they come to "tune out" female IDS, and perhaps "tune in" IDS produced by a more responsive social partner such as a non-depressed father. Research may yet show that infants with intact learning ability reared in environments with a depressed primary caregiver over time learn less about their environment (Cicchetti et al., 2002), and evidence for diminished capacity to learn may yet be obtained in cases when both parents are depressed.

Although the current data are consistent with an experience-dependent explanation of learning deficits in this paradigm, the correlation between maternal sensitivity and infant learning does not necessarily imply a causal relation between the two. Another possibility is that these data may be interpreted based on global effects or correlates of maternal sensitivity. Low maternal sensitivity may itself be linked to poor infant learning through a number of other possible mediators we did not measure. We ruled out some common demographic risk factors as alternative explanations in this sample, but sensitive mothers may have infants with superior learning ability due to some attribute such as higher maternal IQ.

Alternatively, the significant correlation between maternal sensitivity and infant learning may reflect the fact that videotaped play sessions that provided the basis for ratings of maternal sensitivity occurred immediately before conditioned-attention tests. Perhaps more sensitive mothers were better able to put their infants in an optimal state for learning, which carried over into the infant learning sessions and facilitated performance, but in a non-specific way.

Another alternative explanation for learning failures when depressed (and/or insensitive) mothers' IDS signal smiling faces is that infants' prior learning that speech low in the vocal expression of emotion does not "go with" smiling faces prevents them from showing evidence of associative learning in the conditioning session. Evidence suggests that infants can demonstrate sensitivity to the correspondence between certain types of facial expression and vocal prosody (Grossman, Striano, & Friederici, 2006; Walker-Andrews, 1988; although the likelihood of obtaining evidence for this kind of effect is probably increased when voices and faces are presented simultaneously, rather than sequentially as in the conditioned-attention paradigm). Infant failures to learn to associate depressed mothers IDS with a smiling face may result from an affective mismatch between voice and face.

This account might explain infant learning failures in response to depressed mothers' IDS, but it cannot explain learning failures in infants of depressed mothers in response to non-depressed mothers' "high-quality" affectively positive IDS (Kaplan et al., 2004). Clearly, this partially generalized learning deficit suggests either a developmental change in responsiveness to high-quality IDS in infants of chronically depressed mothers, or that infants of chronically depressed mothers differ somehow from infants of mothers with shorter-duration depressive episodes (perhaps in severity of maternal depression) in a manner that produces more pervasive learning deficits. In either case, this finding suggests that nominal affective mismatches between voice and face cannot completely account for infant learning failures in this paradigm.

The idea that sensitive and contingent responding by caregivers improves the "associability" of their IDS is consistent other studies demonstrating a role for contingency in promoting the development of speech perception and production. On the perception side, Kuhl, Tsao, and Liu (2003) found in 9-month-olds that the decline in non-native phoneme discrimination that normally happens after 6 months of age was reversed by exposure to a live adult interaction partner speaking Mandarin Chinese in IDS intonation, but not by exposure to the interaction partner and her speech via videotape, or through an audio tape of the speech only. On the production side, Goldstein and Schwade (2008) showed that contingent but not non-contingent vocal feedback from caregivers resulted in 9.5 month-olds incorporating phonological patterns of caregiver speech into their babble. The common thread linking these findings is the idea that contingent social interactions facilitate speech and language development.

In conclusion, the hypothesis that the quality of mother-infant interactions should predict infant learning in this paradigm led to data which for the first time provide evidence for a link between maternal sensitivity and the learning-promoting effects of IDS. Moreover, the fact that this association remained significant even when maternal depression was controlled for provides initial support for the hypothesis that mother-infant interactions are a behavioral mechanism through which maternal depression exerts its effects on infant learning.

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Table 1
Maternal Demographic and Diagnostic Data

Variable	NDEP	DEP
N	37	18
Age of mother (years)	29.5 (5.1)	29.6 (6.3)
Age of infant (days)	285 (72.7)	309 (63.9)
Ethnicity		
white	24 (64.9%)	5 (27.7%)
Latina	4 (10.8%)	10 (55.6%)
African-American	4 (10.8%)	3 (16.7%)
Asian	3 (8.1%)	0 (0.0%)
Native-American	2 (5.4%)	0 (0.0%)
Marital status		
married	31	9
single	6	9
Mother's education	$6.1\ (1.7)_a$	$4.9\ (1.7)_b$
Family income	6.3 (2.3)	5.1 (2.5)
Number of children	1.5 (0.8)	1.8 (0.9)
BDI score	$8.4\ (7.5)_a$	$26.2\ (9.9)_b$

NDEP = non-depressed mother. DEP = depressed mother. Means labeled with different subscripts are significantly different from one another (p = .05). For family income, 5.0 = $21,000-$30,000, 6.0 = $31,000-$40,000, and 7.0 = $41,000-$50,000 .

Table 2
Looking Times at During Pairing and Summation Test Phases

Phase		**Stimulus**	**Group**
Pairing		*NDEP*	*DEP*
Trial 1	voice	5.59 (3.8)	5.11 (2.9)
	face	7.52 (2.9)	6.43 (3.9)
Trial 6	voice	4.91 (3.9)	5.68 (3.6)
	face	6.39 (3.5)	6.67 (2.3)
Summation Test			
Trial 7	voice + checkerboard	7.87 (1.99)	6.77 (2.15)
Trial 8	checkerboard alone	6.71 (3.03)	6.41 (2.05)
Trial 9	checkerboard alone	5.17 (3.27)	6.06 (2.40)
Trial 10	voice + checkerboard	6.27 (2.40)	5.18 (3.58)
	mean difference score	1.13 (1.94)	-0.26 (1.59)

NDEP = infants of non-depressed mothers; DEP = infants of depressed mothers.

DS = mean difference score in seconds (looking on Trials 7+10 - Trials 8+9).

Table 3

Correlations Among Emotional Availability Scales, Demographic, Diagnostic, Speech Acoustic and Infant Learning Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Ethnicity	—												
2. Education		—	.68**	.44**	.44**	-.31*	.12	.09	.29*	-.23	-.29*	.31*	.28*
3. Income			—	.55**	-.12	-.25	.28*	.04	.30*	-.29*	-.31*	.39**	.34*
4. Marital Status				—	.01	.16	.14	.09	.15	-.19	-.33*	.23	.21
5. Infant Age					—	.16	-.06	.00	.-.20	.20	.13	-.10	-.11
6. DEP						—	-.28	-.31*	-.35**	-.05	.28*	-.35**	-.23
7. F_0							—	-.10	.03	-.03	-.31*	.22	.16
8. Learning Score								—	.35*	.11	-.20	.18	.27
9. Sensitivity									—	-.26	-.66**	.69**	.64**
10. Structuring										—	.19	-.27*	-.32*
11. Hostility											—	-.59**	-.39**
12. Child Resp												—	.83**
13. Child Involve													—

* $p = .05$

** $p = .01$.

Table 4

Zero-Order Correlations

Variable	1	2	3	4	5
1. Demorisk	—	.11	.37**	-.31*	-.12
2. Medication		—	.32*	-.06	-.11
3. Depression			—	-.26*	-.31*
4. Sensitivity				—	.35**
5. Infant Learning					—

* $p = .05$

** $p = .01$.

Table 5

Demographic Risk, Anti-Depressant Medication, Maternal Depression, and Maternal Sensitivity Effects on Infant Learning

Step	Variable	R^2 change	*F* change	df1	df2	Sig. *F* Change
1	Demographic risk	.015	0.66	1	43	.42
2	Antidepressant medication	.024	0.39	1	42	.53
3	Maternal depression	.097	3.29	1	41	.08
4	Maternal sensitivity	.179	4.00	1	40	.05