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Infant-Directed Speech Produced By Fathers with Symptoms of Depression: Effects on Infant Associative Learning in a Conditioned-Attention Paradigm

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Abstract

Infant-directed (ID) speech produced by fathers who varied in their number of self-reported symptoms of depressed was analyzed for differences its ability to promote infant voice-face associative learning. Infants of fathers with elevated scores on the Beck Depression Inventory-II (BDI-II) showed significantly poorer learning than did infants of fathers with non-elevated BDI-II scores when their fathers' ID speech served as a conditioned stimulus for a face reinforcer in a conditioned-attention paradigm. Fathers with elevated BDI-II scores produced ID speech with marginally significantly lower F_0 variability than fathers with non-elevated BDI-II scores. However, F_0-related cues were uncorrelated with infant learning. Overall, fathers' ID speech contained significantly less F_0 modulation than did mothers' ID speech. These findings show that paternal depression, like maternal depression, adversely affects infant learning in a conditioned-attention paradigm.

Keywords

Depression; infant-directed speech; associative learning; fathers; fundamental frequency modulation

Postpartum maternal depression has well-documented effects on maternal functioning and child development (see Murray & Cooper, 1997; Radke-Yarrow, 1998). Approximately 10% of new mothers experience depression in the postpartum period (O'Hara, Neunaber, & Zekoski, 1984), a disorder that can be associated with non-optimal mother-infant interactions (Cohn, Campbell, Matias, & Hopkins, 1990; Field, 1994) and an increased risk for later problems in the child's socio-emotional and cognitive development (Teti, Gelfand, Messinger, & Isabella, 1995; Murray, 1992). However, less is known about the role of the father, either in terms of general facilitative effects on child development (Lamb, 2004), "buffering" effects that non-depressed fathers can have for infants of depressed mothers (Hossain, Field, Gonzales, & Malphurs, 1994), or how depression affects fathers' interactions with their infants (Field, Hossain, & Malphurs, 1999). Here, we report findings from a study that examined the learning-promoting properties of paternal infant-directed (ID) speech in fathers who varied in symptoms of depression.

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A series of experiments in our laboratory has investigated the role of ID speech recorded from depressed versus non-depressed caregivers in promoting a basic kind of learning in young infants. In a conditioned-attention paradigm, an auditory stimulus (conditioned stimulus or CS) signals a salient and socially reinforcing face stimulus (unconditioned stimulus or UCS). In early studies, 4-month-old infants of non-depressed mothers who were given 6 contiguous but non-overlapping pairings of a 10-s tone and a 10-s smiling face reinforcer showed evidence of associative learning. That is, the tone acquired the ability to enhance looking at a checkerboard pattern during a post-conditioning summation test. Such "positive summation" was not evident in control conditions in which tone and face had been presented in backward pairing or random arrangements, or when the face had been presented alone (Kaplan, Fox, & Huckeby, 1992).

In subsequent experiments, 10-s ID or adult-directed (AD) speech segments recorded from unfamiliar mothers were used as CSs, and significant positive summation was observed in 4-month-old infants following forward pairings of ID speech and a smiling face, but not after backward pairings of ID speech and face, or forward or backward pairings of AD speech and face (Kaplan, Jung, Ryther, & Zarlengo-Strouse, 1996). This suggested that maternal ID speech is more effective than maternal AD speech at promoting associative learning in this paradigm.

Because ID speech produced by mothers with comparatively more symptoms of depression was known to possess a significantly lower extent of fundamental frequency (F_0) modulation (Bettes, 1988) — an important acoustic cue in maternal ID speech (Fernald & Kuhl, 1987) — we predicted that ID speech recorded from mothers with comparatively more symptoms of depression would be less effective at promoting voice-face associations in this paradigm. Kaplan, Bachorowski, & Zarlengo-Strouse (1999) recorded brief segments of ID speech from 20 mothers who varied in symptoms of depression, and later used them to signal a smiling face reinforcer for 20 groups of 4-month-old infants of non-depressed mothers. Results of post-conditioning summation tests showed greater positive summation for infants tested with an unfamiliar non-depressed mother's ID speech, and progressively less mean positive summation as the Beck Depression Inventory (BDI) score of the mother who produced the speech sample increased. Acoustic analyses showed a significantly smaller change in fundamental frequency (ΔF_0) in mothers diagnosed with major depressive disorder relative to non-depressed mothers. This study showed that ID speech produced by depressed mothers is less effective than that produced by non-depressed mothers at promoting voice-face associations, and pointed to lower F_0 modulation as a proximate acoustic determinant of this learning deficit.

In a follow-up study, infants of depressed and non-depressed mothers were tested with their own and unfamiliar mothers' ID speech. Four-month-old infants of clinically depressed mothers did not acquire associations when their own or an unfamiliar depressed mother's ID speech signaled a face, but showed significant learning when an unfamiliar non-depressed mother's ID speech served as signal (Kaplan, Bachorowski, Smoski, and Hudenko, 2002). This was consistent with the idea that learning deficits were based on low perceptual salience in "depressed" ID speech, rather than low infant motivation or ability to form associations.

However, in another experiment, older infants of more chronically depressed mothers showed no significant learning in response to non-depressed mothers' "high-quality" ID speech (Kaplan, Dungan, & Zinser, 2004, Exp. 1), with the strength of their learning inversely proportional to the postpartum duration of their mother's current depressive episode. This result occurred in spite of the fact that the perceptual salience of the ID speech was high, and cannot therefore by explained based on disruption of learning by an affective "mismatch" between the ID speech and the smiling face reinforcer. At the same time, these infants showed significantly stronger learning in response to ID speech recorded from an unfamiliar non-depressed father than did age-matched controls of non-depressed mothers (Kaplan et al., 2004, Exp. 2), a finding which ruled out explanations based on general deficits in the infants' motivation or ability to acquire associations. It also suggested that fathers may serve as "natural buffers" against some of the adverse effects of maternal depression on infants (Hossain et al., 1994). However, it was based on only 1 exemplar of paternal ID speech.

Given the apparently privileged status of (non-depressed) fathers' ID speech for infants of depressed mothers, the aim of the current study was to begin a broader investigation of the acoustic and learning-promoting properties of ID speech produced by fathers who varied in their number of symptoms of depression. To date, no published studies have examined the of effects depression on paternal ID speech. Several studies have reported that, when addressing infants, both fathers and mothers simplify their speech, slow speech rate, decrease phrase length, increase repetitions, and alter prosodic structure (Fernald, Taeschner, Dunn, Papousek, de Boysson-Bardies, and Fukui, 1989; Papousek, Papousek, & Haeckel, 1987). Direct comparisons of mothers' and fathers' ID and AD speech in samples of French, Italian, German, Japanese, British English, and American English parents have shown that mothers and fathers consistently produced ID speech with higher mean F_0 and greater F_0 variability relative to AD speech (Fernald et al., 1989). However, fathers did not exhibit as large an F_0 range (ΔF_0) in their ID speech compared with mothers.

The literature on infants' responses to male and female ID speech contains mixed results. At least three studies have reported comparable levels of infant responding to maternal and paternal ID speech. Werker & McLeod (1989) reported that 4- to 5.5- and 7.5- to 9-month-old infants exhibited longer looking times and more positive affective responses to videotapes of both mothers and fathers reciting ID as compared with AD scripts. Pegg, Werker, and McLeod (1992) found that infants as young as 7 weeks of age preferred both female and male ID over AD speech. Finally, our research showed significant voice-face associations in response to ID speech recorded from non-depressed mothers and fathers (Kaplan et al., 2004).

In contrast, some other research suggests that infants respond more strongly to maternal than paternal speech. Although human neonates exhibited a preference for their own mother's over an unfamiliar mother's voices in an operant sucking paradigm (DeCasper & Fifer, 1980), they failed to show a preference for their own father's over an unfamiliar father's voice (DeCasper and Prescott, 1984). Working with older infants in a visual-fixation-based auditory preference paradigm, Ward and Cooper (1999) found that 4-month-old infants did not exhibit a preference for their own father's AD or ID speech over that produced by an unfamiliar father, even though the speech segments were demonstrably discriminable.

The current experiment compared F_0-related cues and learning promoting properties of ID speech produced by fathers who varied in their number self-reported symptoms associated with depression. We predicted that, in parallel to prior findings with mothers, fathers with comparatively higher levels of self-reported symptoms of depression would produce ID speech with lower F_0 modulation and weaker associative-learning-promoting properties.

Method

Participants

Thirty-nine fathers and their 5- to 12.5-month-old infants (M = 277.5 days; SD = 74.8; range: 146 to 385 days; 20 girls and 19 boys) participated in this study. Fathers were recruited using advertisements in *Colorado Parent*, a parenting magazine available at no cost in local supermarkets. In all but two cases, fathers were recruited through mothers, who responded to the advertisement. Mothers participated in a separate study, but data on diagnostics, speech acoustics, and fathers' involvement in child care and play were available from these mothers (see below). The mean age of the fathers at the time of testing was 32.7 years (SD = 6.9), their mean education level was 5.5 (SD = 1.7; where 5.0 = graduated with a 2-year college degree and 6.0 = graduated with a 4-year college degree), and their median family income was 7.0, where 6.0 = $31,000 – $40,000, and 7.0 = $41,000–$50,000). Twenty-three of the fathers (59.0%) were White, 9 were Latino (23.1%), 5 were African-American (12.8%), and 2 were Asian (5.1%).

Apparatus

During conditioned-attention tests, infants were situated in a car seat that was centered in front of a large flat-black board. A 4-in square translucent Plexiglas projection screen was embedded in the board at approximately 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 recorded 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 insure that looking at the projection screen was not an artifact of infants' visual orienting toward the sound source, the loudspeaker 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 approximately 42 cm. Two visual stimuli, a black-and-white slide of a smiling adult female face[1] and a black-and-white 4 × 4 checkerboard pattern (checks subtended 3° of visual angle), were presented using two computer-controlled slide projectors outfitted with shutters.

Speech Stimuli

Speech segments were obtained from fathers during a 3-min recording session. The first two minutes functioned as a warm-up period during which fathers were asked to engage in free play with their infants. Then, fathers were handed a small stuffed toy gorilla and asked to interest their infants in it using the phrase "pet the gorilla" (as in our prior studies on depressed and non-depressed mothers; e.g., Kaplan et al., 1999; 2004). This phase lasted approximately 1 min. From this stream of speech, the first two interrogative (e.g., "Want to pet the gorilla?") and first declarative ("Pet the gorilla") utterances were selected, spliced together in precise temporal sequence across fathers, and repeated once to yield a 10-s speech stimulus ("Want to pet the gorilla? Can you pet the gorilla? Pet the gorilla. Want to pet the gorilla? Can you pet the gorilla? Pet the gorilla"). Mothers' ID speech samples were obtained in the same visit, using the same procedures (order counterbalanced). For two infants, fathers but not mothers participated.

Assessment of Depressive Symptoms

All fathers were administered the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996), a 21-item self-report measure that is widely used instrument for assessing the affective, cognitive, motivational, and physiological symptoms associated with depression. The BDI-II has significant correlations with psychiatric ratings in clinical samples (Steer, Ball, Ranieri, & Beck, 1997). Suggested cut-offs for classifying respondents as "non-depressed" (BDI-II scores ≤ 13) or "depressed" (BDI-II scores > 13) were used in data analyses. Here, we refer to those two categories as "non-elevated" and "elevated," respectively.

Acoustic Analyses of ID Speech Samples

Mean F_0, mean change in F_0 (F_0 range or ΔF_0), and F_0 variability (the standard deviation of F_0) were analyzed for each father's "pet the gorilla" utterances using SpeechStation2 software (Sensimetrics Corporation, Somerville, MA). SpeechStation 2 had also been used in the Kaplan

[1]A female rather than a male face reinforcer was used in the current study because the female face was used in our prior conditioned-attention experiment in which male ID speech served as CS. It was hoped that this would enhance the comparability of the current and prior studies. Although the mismatch between vocal and facial gender may have been noticed by many of the infants, it was a constant across BDI-II conditions, and thus would not seem to account for differences between those conditions (see Kaplan et al., 2004, p. 147; also Discussion Section).

et al. (2001) study. We report analyses of both the "gorilla" portions of the "pet the gorilla" utterances, which were previously linked to maternal depression and infant learning, and the entire "pet the gorilla" utterances, which were not previously reported.

Father Involvement in Child Care and Play

To assess the involvement of fathers in child care and play, mothers were asked to fill out the Child Care Activity Questionnaire (CCAQ; Montague & Walker-Andrews, 2002). The CCAQ is a 19-item scale that asks parents to detail the percentage of time (0% to 100%) that the mother, the father, and both parents jointly devote to specific child care and play activities. For scoring purposes CCAQ items were aggregated into two conceptually distinct scales, father caregiving (e.g., "change baby's diapers," "bathe baby," "feed baby") and father play (e.g., "play with baby," "spend time talking with baby"). The CCAQ has good internal consistency for both mothers and fathers (Montague & Walker-Andrews, 2002).

Procedure

Immediately after filling out informed consent forms, paternal speech samples were obtained. Then, while an experimenter computer-edited the speech samples, the father filled out the BDI-II and a demographic questionnaire. Next, the infant conditioned-attention test was given. Mothers filled out the CCAQ without the fathers present.

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, 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 (mean interobserver reliability = .94, *SD* = .05).

Results

There were no significant differences between fathers in the non-elevated (BDI ≤ 13) versus elevated (BDI > 13) BDI-II categories in ethnicity (proportion under-represented populations = 35.7% vs. 54.6%, respectively, Fisher exact test, $z = 1.08$, $p = .14$), age ($M = 34.1$ years, $SD = 7.5$ vs. $M = 30.3$ years, $SD = 5.5$, $F(1, 37) = 2.48$, $p = .13$), education, ($Md = 6.0$, vs. $Md = 5.0$, Mann-Whitney $U = 0.24$, $p = .80$), income ($Md = 8.0$ vs. $Md = 6.0$, Mann-Whitney $U = 102.5$, $p = .14$), or infant age ($M = 276.7$ days, $SD = 70.87$, vs. $M = 290.5$ days, $SD = 83.3$, $F(1, 37) = 0.02$). Fathers in the two BDI-II categories differed significantly in mean BDI-II scores ($M = 4.91$, $SD = 3.8$, vs. $M = 17.8$, $SD = 4.2$, $F(1, 37) = 90.95$, $p = .001$, $\eta^2 = .71$).

Infant Learning

Infant learning data were unavailable for 7 of the 39 infants (17.9%), who did not complete the test due to excessive fussing (including 1 infant whose father was in the elevated BDI-II category, and 6 infants whose fathers were in the non-elevated BDI-II category). The resulting number of infants in the elevated and non-elevated conditions was 11 and 21, respectively.

Pairing phase—As has been true in all previous conditioned attention experiments from our laboratory (see, for example, Kaplan et al., 1999), there were no significant changes in the durations of looking at the uniformly illuminated projection screen across the six ID speech signal presentations. This was probably due to the fact there were moderately high levels of looking at the uniformly illuminated projection screen during speech segment presentations even on the first pairing trial. The mean durations of looking on Pairing Trials 1 and 6 were 5.8 s and 6.5 s for infants of fathers with non-elevated BDI-II scores, and 4.9 s and 6.8 s for infants of fathers with elevated BDI-II scores. A repeated measures ANOVA using the Greenhouse-Geisser corrected degrees of freedom yielded no significant effects of father's BDI category (1 = elevated, −1 = non-elevated) on looking times during speech segments, $F(1, 30) = 0.11$, $p = .92$, and no significant changes as a function of pairing trials, $F(5, 113) = 1.76$, $p = .13$, and no significant interaction between the two, $F(5, 113) = 0.80$, $p = .52$.

Similarly, there were no changes in the durations of looking at the smiling face reinforcer across trials, with means on Pairing Trials 1 and 6 for infants of fathers with non-elevated BDI-II scores equal to 8.2 s and 7.0 s, and means for infants of fathers with elevated BDI-II scores equal to 7.1 s and 6.8 s. A repeated measures ANOVA using a the Greenhouse-Geisser corrected degrees of freedom yielded no significant effect on looking times during faces of BDI-II category, $F(1, 30) = 0.27$, $p = .61$, pairing trials, $F(4, 128) = 0.79$, $p = .54$, or their interaction, $F(4, 128) = 0.99$, $p = .42$.

Summation test phase—The first four columns of Table 1 show the mean durations of looking at the checkerboard pattern on Test Trials 1–4 (ID speech segments from the pairing phase were presented on trials 1 & 4) for infants of fathers with non-elevated versus BDI-II scores. An ANOVA carried out on these data using Greenhouse-Geisser corrected degrees of freedom showed no significant main effect of fathers' BDI-II category, $F(1, 30) = 0.24$, n.s., but a significant effect of trials, $F(3, 81) = 6.96$, $p = .001$, $\eta^2 = .19$, and a significant interaction between BDI-II category and trials, $F(3, 81) = 4.28$, $p = .01$, $\eta^2 = .13$, observed power = .82. Trend tests revealed significant linear and quadratic trends of trials in the non-elevated condition, $F(1, 20) = 4.66$, $p = .05$, $\eta^2 = .18$, and $F(1, 20) = 17.09$, $p = .001$, $\eta^2 = .45$, respectively, but only a significant linear trend of trials in the elevated condition, $F(1, 10) = 15.57$, $p = .01$, $\eta^2 = .61$.

The final column of Table 1 presents the mean difference scores derived from summation test data, defined as the mean duration of looking at the novel checkerboard pattern when it was presented simultaneously with the speech segment that had signaled the face in the pairing phase, minus that when the checkerboard pattern was presented alone. Values above zero indicate positive summation, i.e., that speech segments increase looking at the checkerboard pattern. Prior research showed that positive summation does not occur in standard control conditions including random, backward, and no-CS controls (Kaplan et al., 1992;Kaplan et al., 1996), including control conditions involving infants of depressed parents, infants of the ages studied here, and infants tested with maternal or paternal ID speech (Kaplan et al., 2004).

Mean difference scores for infants of fathers in the non-elevated BDI-II category ($M = 2.02$ s, $SD = 2.19$) were significantly higher than those for infants of fathers in the elevated BDI-II category ($M = -.59$ s; $SD = 2.14$), $F(1, 30) = 10.68$, $p = .01$, $\eta^2 = .26$. The correlation between father's BDI-II score and infant mean difference score was also significant, $r = -.36$, $p = .05$.[2]

[2]The mean difference score for infants of fathers with non-elevated BDI-II scores was 2.12 s ($n = 11$; $SD = 1.98$) when the infant's mother was also categorized with a non-elevated BDI-II score, and 2.38 s ($n = 10$; $SD = 2.67$) when the infant's mother had an elevated BDI-II score. The mean difference score for infants of fathers with elevated BDI-II scores when the infant's mother had a non-elevated BDI-II score was −1.16 s ($n = 4$; $SD = 3.55$), and when the infant's mother had an elevated BDI-II score, −0.06 s ($n = 6$; $SD = 1.38$). Mothers' and fathers' BDI-II scores did not significantly correlate with one another, $r = .11$, $p = .50$.

Because of the large range of infant ages in this study, we examined the relation between infant age and infant learning. An ANCOVA performed on difference scores with father's BDI-II category as the between factor and infant age as a covariate revealed a main effect of fathers' BDI-II category, $F(1, 29) = 10.23$, $p = .01$, $\eta^2 = .17$, but no significant effect of infant age, $F(1, 29) = 0.21$.[3] Table 2, which presents individual fathers' BDI-II scores, their infants' ages, and mean difference scores from the summation test phase, shows that the absence of an age effect was not due infants of fathers in the elevated BDI-II group being generally older than the controls, with a few outliers reducing the mean age. Table 2 also shows that both younger and older infants of fathers with elevated BDI-II scores failed to acquire associations in response to their own fathers' ID speech. Infant gender (female = 1; male = −1) was uncorrelated with fathers' BDI-II category, $r = .09$, or learning scores, $r = -.07$.

Speech Acoustics

Fathers with elevated BDI-II scores produced ID utterances that had non-significantly lower ΔF_0 in the "gorilla" segments, $F(1, 37) = 2.75$, $p = .11$, and in the entire "pet the gorilla" utterances, $F(1, 37) = 2.47$, $p = .13$, relative to fathers with non-elevated BDI-II scores (M = 73 Hz, SD = 33.7, vs. M = 100 Hz, SD = 46.3; and M = 94 Hz, SD = 43.0 vs. M = 121 Hz, SD = 52.0, respectively). Mean F_0 for "pet the gorilla" utterances did not differ significantly between the two groups, M = 174 Hz, SD = 32.0, vs. M = 187, Hz, SD = 50.1, respectively, $F(1, 37) = 0.62$ (similar results were found for mean F_0 in "gorilla" utterances). However, mean F_0 variability — as measured by the mean standard deviation of F_0 averaged across the three "pet the gorilla" utterances for each father — was marginally significantly lower in the elevated versus non-elevated BDI-II conditions, Ms = 30.0 vs. 41.6, $F(1, 37) = 3.89$, $p = .056$, $\eta^2 = .10$.[4] However, none of the F_0 measures significantly predicted infant difference scores (for ΔF_0 in "gorilla" utterances, $r = .25$, $p = .17$, for ΔF_0 in "pet the gorilla" utterances, $r = .24$, $p = .18$; for mean F_0, $r = .07$, for F_0 variability, $r = .14$, $p = .45$).

Mean ΔF_0 for "pet the gorilla" utterances was significantly higher for mothers' than fathers' ID speech, M = 151 Hz, SD = 72.1, vs. 94 Hz, SD = 45.6, respectively; paired $t(34) = 4.39$, $p = .001$ (data were unavailable from 3 mothers). This difference held true regardless of BDI-II category: elevated BDI-II category: Ms = 143 Hz, n = 18, vs. 79 Hz, n = 12, independent $t(28) = 3.35$, $p = .01$; non-elevated BDI-II category: M = 165 Hz, n = 18, vs. M = 99 Hz, n = independent $t(44) = 3.45$, $p = .01$.

Father Involvement in Child Care and Play

Fathers with elevated BDI-II scores were rated by mothers as more engaged in the total child care effort than were fathers with non-elevated scores, Ms = 24.1% vs. 15.3% for child care, $F(1, 30) = 3.71$, $p = .05$, $\eta^2 = .10$. There were no differences in maternal ratings of fathers' involved in play, Ms = 27.4% vs. 25.1%, $F(1, 30) = 0.75$, n.s. However, the reported percentage of total child care performed by fathers did not correlate with difference scores obtained in tests with the father's ID speech, $r = -.11$, $p = .59$, with ΔF_0 for "gorilla" or "pet the gorilla" utterances, $r = .11$, $p = .54$, and $r = .11$, respectively, or with F_0 variability, $r = .10$.

[3] Another way to examine the role of infant age is to hold it roughly constant. A comparison of differences scores calculated from test trial data for 10- to 12.5-month-old infants of fathers in the non-elevated (mean age = 346 days, SD = 30.1) vs. elevated (mean age = 344 days, SD = 34.8) BDI-II categories again showed evidence of learning only in the non-elevated condition, Ms = 1.79 s, SD = 1.84, n = 9, and −0.46 s, SD = 2.47, n = 6, respectively, $t(13) = 2.03$, $p = .063$, 2-tailed.

[4] Infant age was not significantly correlated with paternal ΔF_0 for "pet the gorilla" utterances, $r = .09$, or with F_0 variability, $r = .20$, $p = .23$. Mothers' BDI-II category did not significantly predict any of the F_0–related acoustic measures in paternal ID speech (highest $r = -.16$, $p = .35$, for mean ΔF_0 for the "gorilla" portion of the "pet the gorilla" utterance).

Discussion

Infant-directed speech recorded from fathers with elevated scores on the BDI-II promoted significantly weaker voice-face associative learning than that recorded from fathers with non-elevated BDI-II scores. There was a marginally significant relation between paternal BDI-II category and mean F_0 variability in paternal ID speech, but none of the F_0-related measures predicted infant learning. As in some prior research (Fernald et al., 1989), ID speech produced by fathers contained significantly smaller ΔF_0 than that produced by mothers, regardless of BDI-II category. Mothers rated fathers with elevated BDI-II scores as more involved in child care relative to fathers with non-elevated BDI-II scores, but father involvement in child care did not predict infant learning scores. These findings show that, as with mothers, elevated symptoms of depression in fathers are linked to poorer infant learning in response to paternal ID speech.

As was reviewed above, Kaplan et al. (2004) showed that infants of chronically depressed mothers failed to learn in this paradigm in response to ID speech produced by their own depressed mother or an unfamiliar non-depressed mother, but showed better-than-normal learning in response to ID speech produced by an unfamiliar non-depressed father, relative to infants of non-depressed mothers. However, although they were obtained in tests with the infant's own, instead of an unfamiliar fathers', ID speech, the current findings showed that elevated depressive symptoms have similar adverse effects on the learning-promoting properties of fathers' as they do with mothers' ID speech. These data suggest that the better-than-normal learning in response to an unfamiliar father's ID speech by infants of chronically depressed mothers will likely not occur when the infant's father is depressed. Infants whose mothers and fathers are both depressed may show the broadest associative learning deficit in this paradigm.

An unusual aspect of the conditioning arrangement used here was that fathers' ID speech segments signaled female faces. As was mentioned above, this was done to hold constant the procedure used in a prior study that had yielded evidence of significant voice-face associations (Kaplan et al., 2004; Exp. 2). Because this was true for all infants regardless of their fathers' BDI-II category, we have argued that this feature of the conditioning arrangement cannot itself account for our results (see footnote #1). However, it may be that infants of fathers with elevated BDI-II scores were more likely to notice the voice-face gender mismatch because of their fathers' greater reported involvement in their care. Under this hypothesis, detection of the voice-face mismatch disrupts associative learning through low CS-UCS similarity or prior learning that fathers' voices do not "go with" mothers' faces. An important implication of this hypothesis was disconfirmed, however, by the finding that mothers' CCAQ ratings of fathers' involvement in child care did not predict infant learning.

Relative to maternal ID speech, paternal ID speech contained significantly smaller F_0 range. This finding replicates that of Fernald et al. (1989) in a study comparing mothers and fathers in several different language cultures, but perhaps should be interpreted with caution given the possibility that fathers were more uncomfortable or self-conscious than mothers at engaging in fully animated ID speech in the laboratory. Even so, this would not account for differences in F_0 measures between fathers with non-elevated versus elevated BDI-II scores.

ΔF_0 and F_0 variability differed in the predicted direction, although not significantly so, between fathers in the two BDI-II categories, but neither measure alone or in combination significantly predicted infant learning. However, with a larger sample of fathers significant results yet might be obtained. In addition, acoustic cues in ID speech, more broadly construed, might be shown to fully mediate the effect. ID speech is an acoustically rich signal, and the larger empirical literature on the perceptual salience of ID speech shows that a combination of several acoustic cues, possibly including harmonic information and spectral cues associated with supralryngeal vocal-tract filtering (i.e., formant or resonant properties) may best account for the differential responding between ID and AD speech (Colombo, 1985; Cooper and Aslin, 1994; Fernald and Kuhl, 1987; Kaplan et al., 1995; Katz, Cohn, & Moore, 1996).

A related possibility is that the stronger responding to ID speech produced by fathers with non-elevated in comparison with elevated BDI-II is attributable to difference in the vocal expression of emotion. Trainor, Austin, and Desjardins (2000) showed that acoustic differences between ID and AD speech are minimized or disappear entirely when emotional content is held constant. Singh, Morgan, and Best (2002) provided support for this position by showing that 6-month-old infants' listening preferences for ID over AD speech were eliminated when the emotional tone was held constant. Further, emotional tone seemed to be a primary determinant of infant responding, and F_0 characteristics a secondary determinant when the two were varied independently. Similarly, Kitamura and Burnham (1998) found that when emotional tone was held constant, infants showed no preference for ID over AD speech that varied in pitch characteristics, and when pitch characteristics were held constant, infants did show a preference for happy sounding ID speech over affectively neutral ID speech. Singh et al. (2002) suggested that particular vocal emotions are not easily distinguished based on specific acoustic features, but rather that a constellation of parameters including F_0 characteristics, intonation, loudness, formant frequencies, and speech rate are involved.

Thus, although F_0 characteristics of ID speech produced by fathers with elevated versus non-elevated BDI-II scores in the current study did not correlate with infant learning in response to the infant's own father's ID speech, differences in perceived vocal expression of emotion may have played an important role in infant learning outcomes. Infants may not be motivated to learn in response to emotionally flat ID speech, or they may have previously learned that emotionally flat ID speech does not "go with" a smiling face. An initial step toward testing the first hypothesis might be to determine whether adults' ratings of the emotional tone of depressed and non-depressed fathers' ID speech predict infant learning outcomes in this paradigm. The second hypothesis can be tested by determining whether infants of depressed and non-depressed mothers show evidence for associative learning when ID speech produced by a depressed caregiver signals a sad face.[5]

However, if the low perceptual salience or flatter emotional tone of depressed fathers' ID speech cannot completely explain infant learning failures, perhaps a more comprehensive account can derive from a consideration of the acquired significance (or insignificance) of depressed parents' ID speech. A large body of research points to disordered mother-infant interactions as a significant correlate of maternal depression (Cohn & Campbell, 1992), and one that may affect infant cognitive development through consequences of dysregulated arousal and attention (Field, 1994; Tronick & Gianino, 1996). Prolonged interactions with a partner who is low in sensitivity and contingent responding, as are depressed caregivers (Bettes, 1988; Murray et al., 1993; Zlochower & Cohn, 1991) may, through a conditioning process such as latent inhibition (Lubow, 1989) or learned irrelevance (Linden et al., 1997), teach an

[5]Prior research in our laboratory has investigated whether matches versus mismatches in affective information in voices and faces affect infant learning. For example, Kaplan et al. (1997) showed that ID speech rated as happy-sounding by adults was equally well associated with a smiling or a sad face by four-month-old infants of non-depressed mothers. However, ID speech rated by adults as soothing/consoling was more readily associated with a sad than a happy face by these infants. Interestingly, AD speech rated by adults as sad-sounding did not promote associative learning with either a sad or smiling face. Unpublished work from our lab shows that, similarly, AD speech rated as happy-sounding by adults did not promote associative learning with either a sad or smiling face. These latter findings are in contrast to those from preference paradigms suggesting that differences in responding to ID vs. AD speech are due primarily to differences in emotional tone (e.g., Kitamura & Burnham, 1998; Singh et al., 2002; Trainor et al. 2000). More recent work from our laboratory showing that infants of chronically depressed mothers do not acquire associations when happy-sounding ID speech from non-depressed mothers predicts a smiling female face suggests that nominal affective mismatches between voice and face cannot completely account for infant learning failures in this paradigm.

infant that stimuli associated with this partner are uncorrelated with reinforcing events. In a related vein, such interactions may lead to conditioned negative emotional states. Infant responding in conditioned-attention tests may reflect in part a “transfer of training effect,” in which this prior learning interferes with (or, in the case of non-depressed parents, potentially facilitates) the acquisition of voice-face associations (see Dunham & Dunham, 1990; Hay, 1997; Stanley, Murray, & Stein, 2004, for discussions of apparent transfer of training effects). If so, the quality of parent-infant interactions may predict the effectiveness of the mother’s and father’s ID speech at promoting voice-face associative learning.

The implications of these findings beyond infancy remain to be determined. There are important direct and indirect roles for fathers in child cognitive development (Lamb, 2004, pp. 103–104). For example, in a sample of 2- to 3-year-old children enrolled in Early Head Start programs, both fathers’ and mothers’ “supportive parenting” (a composite of sensitivity, positive regard, and cognitive stimulation) predicted language and cognitive development (Tamis-LeMonda, Shannon, Cabrera, & Lamb, 2004). We identified a specific deficit in paternal cognitive stimulation that may be present from an early age for infants of depressed fathers. Along with a diminished ability to buffer adverse effects of maternal depression on child development, depression in fathers may contribute directly to child cognitive developmental delays.

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Table 1

Mean Durations of Looking on Test Trials and Mean Difference Scores in Seconds

Group	Test Trial				
Father's BDI-II Category	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**DS**
Non-elevated	7.99 (2.39)	5.83 (2.25)	5.00 (2.90)	6.88 (2.99)	2.02 (2.19)
Elevated	7.42 (2.28)	7.26 (2.06)	5.49 (2.55)	4.17 (3.27)	−0.58 (2.14)

Numbers in parentheses are standard deviations. DS = mean difference score; see text for how these were calculated. Speech segments from the pairing phase were presented simultaneously with the checkerboard pattern on Test Trials 1 and 4, but not on Test Trials 2 and 3.

Table 2

Infant Age, Father's BDI Score, and Mean Summation Test Difference Score

Infant Age	Father's BDI Score	Mean Difference Score (s)
146	21	−1.10
166	2	1.95
167	1	4.95
169	16	−1.55
193	4	0.35
195	24	−0.95
199	5	0.75
207	7	3.20
211	3	0.45
224	5	1.75
227	12	5.95
235	3	−0.35
243	8	7.10
249	16	2.80
257	1	−0.85
276	12	3.15
296	2	1.60
298	14	−1.05
302	7	1.05
308	16	−2.25
335	6	−0.05
342	11	0.10
343	10	3.15
346	23	−0.40
348	0	2.45
355	19	0.30
364	7	5.65
369	1	1.90
371	14	−0.55
373	17	−4.65
383	7	0.80
385	14	2.95