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Maternal Sensitivity During the First 3½ Years of Life Predicts Electrophysiological Responding to and Cognitive Appraisals of Infant Crying at Midlife

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This study examined the predictive significance of maternal sensitivity in early childhood for electrophysiological responding to and cognitive appraisals of infant crying at midlife in a sample of 73 adults (age = 39 years; 43 females; 58 parents) from the Minnesota Longitudinal Study of Risk and Adaptation. When listening to an infant crying, both parents and nonparents who had experienced higher levels of maternal sensitivity in early childhood (between 3 and 42 months of age) exhibited larger changes from rest toward greater relative left (vs. right) frontal EEG activation, reflecting an approach-oriented response to distress. Parents who had experienced greater maternal sensitivity in early childhood also made fewer negative causal attributions about the infant's crying; the association between sensitivity and attributions for infant crying was nonsignificant for nonparents. The current findings demonstrate that experiencing maternal sensitivity during the first 3½ years of life has long-term predictive significance for adults' processing of infant distress signals more than three decades later.

Keywords: parental sensitivity, childhood development, infant distress, electrophysiology, cognitive appraisal

Developmental theorists propose that early experiences with primary caregivers have implications for individuals' thoughts, feelings, and behaviors in social relationships across the life span (e.g., Bowlby, 1969/1982, 1988). Indeed, research leveraging prospective, longitudinal data has repeatedly demonstrated that experiencing more sensitive care in childhood is associated with better outcomes in the salient social developmental domains of adulthood, including the capacity to have high-quality romantic rela-

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tionships (e.g., Haydon, Collins, Salvatore, Simpson, & Roisman, 2012; Oriña et al., 2011; Zayas, Mischel, Shoda, & Aber, 2011) and to engage in supportive, sensitive parenting behavior (Belsky, Hancox, Sligo, & Poulton, 2012; Brook, Lee, Finch, & Brown, 2012; Raby, Lawler, et al., 2015; Szepsenwol, Simpson, Griskevicius, & Raby, 2015). Recent investigations of both normative-risk (Fraley, Roisman, & Haltigan, 2013) and higher-risk cohorts (Raby, Roisman, Fraley, & Simpson, 2015) indicate that experiencing sensitive care during early childhood (e.g., up to age 3½ years) is related to subsequent social competence in an enduring manner up to age 32 years, such that the magnitude of this association remains stable over time rather than approaching zero at the limit. Although these findings reflect significant advances in knowledge regarding the impact of early experiences on adult functioning, plausible mechanisms that explain *why* the effects of early experiences carry forward into important interpersonal contexts of adulthood are still not well understood.

Bowlby (1988) suggested that early childhood experiences with primary caregivers contribute to the development of regulatory response patterns to, as well as appraisals of, one's own and others' behavior during social interactions across the life span. Guided by this framework, internal working models of early parent–child relationships have been considered a possible mechanism underlying associations between childhood caregiving experiences and later interpersonal functioning (e.g., Grossmann, Grossmann, Kindler, & Zimmermann, 2008; Roisman, Madsen, Hennighausen, Sroufe, & Collins, 2001; Szepsenwol et al., 2015). Although internal working models represent one plausible *psychological* process that may account for the persisting influence of early caregiving experiences on adult social functioning, research from the Minnesota Longitudinal Study of Risk and Adaptation (MLSRA; Sroufe, Egeland, Carlson, & Collins, 2005) suggests that physiological and cognitive mechanisms also warrant further investigation.

Raby, Roisman, Simpson, Collins, and Steele (2015), for instance, found that childhood experiences characterized by maternal *in*sensitivity are associated with physiological responses of the autonomic nervous system that indicate behavioral inhibition during conflict discussions with romantic partners in adulthood. In other words, individuals who experienced less sensitive caregiving during childhood generated physiological responses thought to reflect motivational tendencies to avoid or ignore relational conflict. Additionally, Waters, Ruiz, and Roisman (2017) found that experiencing maternal sensitivity during childhood is also associated with cognitive mechanisms tied to adults' relational behavior. Specifically, adults who experienced greater maternal sensitivity during childhood also had better awareness of cognitive scripts regarding caregivers' potential availability as a responsive provider of comfort in response to a child's distress (i.e., secure base script knowledge; Waters et al., 2017). More awareness of these cognitive scripts is also associated with greater parenting competence in adulthood (Waters, Raby, Ruiz, Martin, & Roisman, in press). Viewed together, these findings highlight the need to identify physiological responses and cognitive processes that may explain the enduring predictive significance of early caregiving experiences on adult social development.

The current study extends prior research by exploring specific physiological and cognitive processes by which early caregiving experiences may be linked to adults' social functioning in a salient social context during adulthood. Specifically, we explored the predictive significance of experiencing maternal sensitivity in early childhood for adults' electrophysiological responding to (i.e., change in EEG asymmetry) and cognitive appraisals (i.e., causal attributions) of infant distress signals (i.e., crying) in a laboratory paradigm (see Groh & Roisman, 2009; Groh et al., 2015).

Change in frontal EEG alpha asymmetry from rest in response to an emotionally evocative stimulus is believed to reflect an individual's tendency for either an approach-oriented or withdrawal-oriented response to the stimulus, as evidenced by a change to greater relative *left* or greater relative *right* activation, respectively (see Coan & Allen, 2004). Researchers have shown that infant distress signals elicit distinct patterns of change in EEG asymmetry from rest, depending on adults' awareness of cognitive scripts regarding appropriate attachment-figure roles (i.e., secure base script knowledge). For instance, in one study, mothers with more secure base script knowledge exhibited changes toward greater relative right (vs. left) frontal EEG activation from rest in response to infant distress (Groh et al., 2015), reflecting a withdrawal-oriented response. These authors interpreted this change as reflecting a maternal response that was qualitatively similar (i.e., negative) to the infant's own emotional distress. This particular pattern of change in frontal EEG asymmetry has also been linked with mothers' greater concern/worry about infant distress and their more sensitive behavior when interacting with their children (Killeen & Teti, 2012). Although these findings support the hypothesis that experiencing greater maternal sensitivity during childhood might be related to changes toward greater relative *right* frontal EEG activation in response to infant crying, the opposite pattern of greater relative *left* frontal EEG activation can also be hypothesized.

Most notably, researchers have previously reported that mothers who demonstrated more sensitive caregiving in routine child-care situations (e.g., feeding, clothing) had infants who tended toward greater relative left frontal EEG asymmetry at both 9 months (Hane & Fox, 2006) and 3 years of age (Hane, Henderson, Fox, & Reeb-Sutherland, & Fox, 2010). Conversely, less sensitive maternal care was consistently associated with a pattern of greater right frontal EEG asymmetry at both ages (Hane & Fox, 2006; Hane et al., 2010). Researchers have also found children's greater left frontal EEG asymmetry to be associated with more social competence and positive affect, as well as less social withdrawal and negative emotion during social interactions with mothers and peers compared to children who demonstrate greater right frontal EEG asymmetry (e.g., Buss et al., 2003; Fox, Bell, & Jones, 1992; Fox et al., 1995). Presuming that adults with greater left versus right frontal EEG activation would display similar pattern of greater relative left frontal EEG asymmetry to be linked with a more competent, affectively controlled response during social interaction, such as exposure to infant distress (i.e., crying). Thus, although these prior studies did not examine focal associations beyond childhood and measured resting state rather than changes in frontal EEG asymmetry, their combined results can be used to support the hypothesis that experiencing greater early maternal sensitivity may predict a change toward greater relative left frontal EEG asymmetry in response to infant crying.

Regarding adults' cognitive appraisals of infant crying, attributing an infant's cries as having negative or internal causes such as "the baby is crying because she is spoiled" interferes with the caregivers' ability to respond sensitively (Leerkes, Su, Calkins, Supple, & O'Brien, 2016; Leerkes et al., 2015), perhaps because they deem the infant's distress as undeserving of a supportive response. Childhood caregiving experiences during the first few years of life are thought to influence how adults appraise others' behavior in later social interactions, including those with infants (Bowlby, 1988). Indeed, mothers who retrospectively report experiencing less emotional rejection from their own caregivers during childhood and mothers who possess characteristics of secure attachment representations make fewer negative attributions for infants' crying (Leerkes & Siepak, 2006; Leerkes et al., 2015), which suggests that adults' own caregiving-related experiences may be associated with how infant distress cues are interpreted by adults. However, prospective longitudinal evidence is needed as further support.

The Current Study

This is the first study to examine associations between early maternal sensitivity and adults' electrophysiological responses to and cognitive appraisals of infant distress. Sensitivity during *early* childhood was the focus of the current study for both theoretical and empirical reasons. First, early childhood has been identified as a key developmental period during which relational experiences with primary caregivers are incorporated into the individual's developing model of how to behave in interactions within important relationships throughout the life span (Bowlby, 1969/1982, 1988). Second, research suggests early childhood to be especially salient for the enduring significance of maternal sensitivity on adult social competence, such that experiencing maternal sensitivity prior to age 3 years accounts for social functioning through mid-adolescence beyond the impact of concurrent associations with maternal sensitivity in later childhood (Fraley et al., 2013).

This research was guided by one exploratory and one directional hypothesis. With regard to EEG responding, two plausible hypotheses could be posed. Based on the existing research described above, early maternal sensitivity may be associated with changes toward greater relative *right* EEG activation, reflecting a withdrawal-oriented emotional response that is empathically matched (i.e., negative) to the infant's distress, *or* with changes toward greater relative *left* EEG activation, reflecting an approach-oriented response to infant distress. Given these two possible hypotheses, this research question remained exploratory. Additionally, we hypothesized that higher levels of early maternal sensitivity would be associated with fewer negative appraisals of infant crying in adulthood. To determine whether these associations were unique to *early* childhood, maternal sensitivity during *later* childhood was controlled in analyses. The robustness of the hypothesized prospective, longitudinal associations was also tested controlling for a standard set of potential demographic confounds.

Method

Participants

Between 1975 and 1977, 267 pregnant women living below the poverty line and receiving prenatal services through the local health department in Minneapolis, Minnesota, were initially recruited for the MLSRA (Sroufe et al., 2005), an ongoing study of development from infancy through adulthood. At the child's (i.e., target participant's) birth, 48% of mothers were teenagers, 65% were single mothers, and 42% had not completed high school. These children continued to participate in the project throughout their lives, including an assessment of adult cognitive, social, and physical functioning at age 39 years. All active MLSRA participants ($N = 167$) were contacted with information about this assessment and were invited to participate. Of these, 62 declined to take part in the lab-based EEG assessment, 2 were incarcerated and thus unavailable, and 28 could not be reached. Seventy-five individuals (44 female) completed the in-lab assessment. Data from two individuals (1 female, 1 male) who had received electric shock therapy or had been diagnosed with epilepsy or multiple sclerosis were excluded from the analyses given their risk for atypical EEG activity, resulting in a final analytic sample of $N = 73$.

The analytic sample did not differ from the original MLSRA participants who did not complete the 39-year assessment in terms of ethnicity (White vs. non-White), $\chi^2(1) = .03$, $p > .25$, Cohen's $d = .02$; mother's education, $t(264) = -1.60$, $p = .111$, Cohen's $d = .22$; occupation, $t(264) = -1.00$, $p > .25$, Cohen's $d = .15$; or mother's marital status at birth (65% analytic vs. 65% original), $\chi^2(1) = .002$, $p = .966$, Cohen's $d = .01$, or with respect to early maternal sensitivity, $t(241) = .33$, $p = .739$, Cohen's $d = .05$. However, females were overrepresented in the analytic sample compared to the original participants (59% analytic vs. 40% original), $\chi^2(1) = 7.50$, $p = .009$, Cohen's $d = .34$. Within the analytic sample, 66% were Caucasian, 11% were African American, 20% were mixed race, and 3% were Hispanic, Native American, or Asian American. Roughly half (53%) of the sample had a high school level (or GED) education, 10% had completed a technical certificate program, 26% had attained a college degree, and 7% had completed a master's degree or higher; 4% of the sample did not finish high school. A majority (80%) of the analytic sample were parents who had raised, on average, 1.77 children from infancy (range = 0–7). Of these, 95% had at least one biological child; 25% had at least one stepchild; 28% identified as the parent of a nonbiological, nonfoster child; and 2% were the parent of one adopted child. Identifying as a parent did not differ significantly across male and female participants (74% of males vs. 84% of females), $\chi^2(1) = 1.17$, $p = .280$, Cohen's $d = .26$, but females were marginally more likely to have raised a child from infancy (57% of males vs.77% of females), $\chi^2(1) = 3.30$, $p = .069$, Cohen's $d = .44$.

Procedure

Childhood procedures. Throughout childhood, target participants completed videotaped assessments that prospectively tracked their development in several domains, including a series of interactions with their mothers in early (3, 6, 24, and 42 months) and later (13 years) childhood periods. Maternal sensitivity was coded from these interactions. (Additional details regarding the specific tasks and coding of maternal sensitivity are reported below.)

Adulthood procedures. Adult participants were seated in a comfortable living room environment in the laboratory where physiological sensors measuring EEG and eye movements (electrooculography [EOG]) were applied. Following a brief habituation period, participants completed a standard EEG baseline assessment comprising eight 1-min epochs in which they were instructed to keep their eyes open (and focused on a cross in front of them) or closed (an equal number of epochs of eye open/closed; the order was counterbalanced; Allen, Coan, & Nazarian, 2004; Tomarken & Davidson, 1994; Towers & Allen, 2009). Following the baseline period, participants were told they would hear an audio recording of an infant through headphones. They were instructed to close their eyes and imagine how they would respond if the infant was their own child. The audio recording of infant crying was the same one used in prior research (Groh & Roisman, 2009; Groh et al., 2015). As in prior research, participants listened to the infant distress vocalization for 3 min at a constant volume (the peak amplitude of each cry averaged 88.92 decibels, SD = 2.29). After listening to the infant crying, participants then reported their explanations for the infant's behavior by completing the Parental Attributions for Infant Crying questionnaire (Leerkes & Siepak, 2006). All procedures of this research were approved by the University of Minnesota's Institutional Review Board (project name: "Early Life Stress, Developmental Processes, and Adult Health," protocol number: 1104S98312).

Measures

Maternal sensitivity. Maternal sensitivity was rated by trained coders throughout each target participant's childhood from the videotaped observations described above of mother–child interactions during both early (3, 6, 24, and 42 months) and later (13 years) developmental periods.

Early sensitivity. When target participants were 3 and 6 months of age, in-home observations were made during mother–infant feeding sessions. During these feeding sessions, mothers were asked to behave as they normally would with their child. At 6 months, mother–child dyads also completed semistructured play interactions; during these interactions, mothers played with their child first with no toys, and then toys were introduced one at a time and mothers were asked to demonstrate some aspect of each toy to the infant. Finally, mothers and their infants were observed during a free-play interaction with all toys from the previous step. Maternal sensitivity during these tasks was defined as the mother's ability to perceive and correctly interpret her infant's signals, along with her ability to respond appropriately and in a timely manner, and was rated from 1 (low) to 9 (high) using Ainsworth's sensitivity scale (Ainsworth, Blehar, Waters, & Wall, 1978). Mothers rated low on this scale were inattentive and insensitive to the baby's state or were completely unresponsive to obvious cues. In contrast, mothers rated high on this scale were sensitive to the baby's states and needs and were consistently responsive and attentive. The maternal sensitivity rating at 6 months was averaged across feeding and play interactions. Interrater reliability for the 3-month sensitivity ratings was determined using the Lawlis-Lu index (Tinsley & Weiss, 1975), with agreement defined as a discrepancy of 2 or fewer points on the 9-point rating scale. The Lawlis-Lu chi-square test was significant ($p < .05$), with a T value of .75, indicating moderate to high interrater agreement. Intraclass correlations (ICCs) were calculated for the 6-month ratings, and they revealed good interrater agreement (ICC = .89).

At both 24 and 42 months, children (target participants) were observed completing a series of four problem-solving tasks with their mother. In each task, a problem was introduced to mother and infant, and the dyad worked together to arrive at a solution. For example, at 24 months, the first problem involved an apparatus made of two boards and a slot, within which a toy was placed; the child was given a stick, which could be used to remove the toy. At 42 months, the first problem consisted of the dyad needing to build a copy of large wooden block shapes using a set of smaller wooden blocks. At both ages, the problem-solving tasks became increasingly complex such that they were eventually impossible for the child to complete without the mother's assistance. Regardless, mothers were told to allow their child to try to complete each task independently and then to interject with whatever help they believed the child needed. Maternal sensitivity was rated from these problem-solving tasks on a scale from 1 (low) to 7 (high) based on the degree to which mothers served as a secure base (i.e., supportive presence) for their child and how positively engaged they were during the interaction with their child across the increasingly complex tasks. Mothers rated low on this scale were either completely aloof or unavailable or actively hostile toward the child when they required some support. Mothers rated high on this scale were able to provide support throughout, set the child up for success, and restructured the task following child errors to ensure and celebrate some child success. ICCs calculated for the 24- and 42-month sensitivity ratings indicated good interrater agreement at each age (ICC = .84, .87, respectively).

Based on a prior exploratory factor analysis (Raby, Roisman, Fraley, et al., 2015) of all available data for 3-, 6-, 24-, and 42-month sensitivity ratings, a composite score was computed across all four sensitivity ratings to index *early sensitivity*. Specifically, sensitivity ratings at each age were standardized, and the standardized values were then averaged to create the early sensitivity composite index (Cronbach's α = .71).

Later sensitivity. Target participants also completed a series of three collaborative problem-solving tasks in collaboration with their mother in a laboratory setting when they were 13 years old. Specifically, dyads worked together to come up with ideas for an antismoking campaign, to assemble an object while the mother was blindfolded, and to think of possible results of two imaginary scenarios. Videos of the collaborative tasks between the adolescent and his or her mother were rated on a scale from 1 (low) to 7 (high) based on the degree to which mothers served as a secure base (i.e., supportive presence) for their adolescent child during the tasks and how positively engaged mothers were during the interaction. Mothers rated low on this scale did not provide adequate emotional support to the child; this may have been by completely failing to be supportive, providing minimal support or sporadic support, or giving support that appeared to the rater to be insincere and poorly timed. In contrast, mothers rated high in supportive presence demonstrated confidence in the relationship throughout the tasks, responded to the adolescent child's requests and needs for assistance, and provided encouragement when the child appeared distressed or frustrated. This 13-year supportive presence rating had good interrater reliability, with an ICC of .86. These scores were standardized for use in analyses.

EEG.

Data acquisition. EEG and EOG data were continuously recorded at 1,024 Hz with an online bandpass filter of .01 Hz to 100 Hz during baseline and infant crying periods using a Snapmaster Data Acquisition System (HEM Data Corporation, 2000) and James Long, Inc. bioamplifiers (Caroga Lake, NY). EEG was recorded using a 22-channel cap with tin electrodes spaced equidistantly using the 10/20 system. All EEG sites were referenced online to Cz, and Afz served as the ground. Electrodes were also placed below and near the outer canthus of each eye to record vertical and horizontal EOG for offline eye-movement artifact correction. The impedance for each EEG electrode site was kept below 5 kΩ and below 10 kΩ for EOG sites.

Data processing. Given theoretical models implicating frontal EEG asymmetry with emotional responding, our a priori focus was on frontal EEG asymmetry. Accordingly, the results were analyzed for two frontal scalp sites commonly used in the extant literature (F3 and F4). Data were processed offline with both manual and automated routines using EEGLAB (Delorme & Makeig, 2004), a toolbox written in MATLAB (MathWorks, Inc., 2013). After importing into EEGLAB, two sets of filtered data were created for the purpose of artifact rejection: one with a bandpass frequency of 1 Hz to 30 Hz and a second with a 1- to 55-Hz range. Both data sets were re-referenced to linked mastoid channels (A1 and A2). The narrower bandwidth of the first data set allowed a cleaner decomposition of artifacts, so it was used primarily for this purpose. First, continuous data from the narrow bandwidth data set were visually inspected for movement and other gross artifacts, and these marked periods were excluded. Second, the narrow bandwidth data set was submitted to an independent component analysis (ICA) to statistically estimate ocular activity within continuous EEG activity. These results were then applied to the second data set so that ocular artifacts could be rejected and frequency analysis could be performed within a more broadband data set. In the broadband data set, EEG from each experimental condition was segmented into 2-s-long epochs with 50% overlap. The resulting segments were then submitted to a semiautomatic rejection procedure that identified epochs with abnormal kurtosis values (> 3 *SD*s) to flag potentially noisy EEG epochs. Participants' data were then manually reviewed to identify and mark ocular artifacts for removal using the results of the ICA described above and to verify the results of the epoch rejection procedure. Ocular independent components (ICs) were subtracted and marked epochs were excluded to create the data sets used for estimating alpha power. Subtraction of ocular artifacts corrected the data (i.e., retained data points while changing the underlying source structure), and the epoch rejection procedure excluded those epochs from future analysis.

Artifact-corrected data were then submitted to a fast Fourier transform to extract total power within the EEG alpha frequency band (7–14 Hz) for relevant EEG sites within each condition (in microvolts squared, μV^2). Raw alpha power from both F3 and F4 during baseline infant crying conditions was natural logarithm (ln) transformed to normalize the distribution of alpha power for use in the analyses. Alpha asymmetry scores during baseline and cry conditions were created by subtracting the left ln-transformed power value from the right ln-transformed power value (i.e., ln[F4]–ln[F3]). Cortical activity is inversely related to observed alpha power (Davidson, 1988), such that when more alpha activity is observed over one hemisphere relative to the other, the hemisphere with less alpha power is thought to be more cortically active than the hemisphere with more alpha power. Thus, *positive asymmetry scores* reflected greater relative left cortical activity (vs. right), and *negative asymmetry scores* reflected greater relative right cortical activity (vs. left) during baseline and infant crying conditions. Finally, a change in frontal EEG asymmetry score was calculated for use in analyses by subtracting frontal EEG alpha asymmetry during baseline from frontal EEG alpha asymmetry during the experimental condition (infant crying). This change score indicates a change toward greater left (*positive change score*) or greater right (*negative change score*) frontal EEG activation in response to the infant cry stimulus; no change from baseline toward either greater relative left or right frontal EEG activation in response to infant crying would be evidenced by a score of zero.

Cognitive appraisals of infant crying. After listening to the infant crying, participants rated the degree to which they agreed with a list of 18 reasons for the infant's crying (Parental Attributions for Infant Crying; Leerkes & Siepak, 2006). Responses were made on a 4-point scale ranging from *strongly disagree* (1) to *strongly agree* (4). Researchers have previously used three subscale scores from this measure: *minimizing attributions* (five items: having a bad day, in a bad mood, tired, hungry, not feeling well; Cronbach's $\alpha = .55$), *negative/internal attributions* (7 items: spoiled, difficult temperament, trying to make mother's life difficult, unreasonable, crying on purpose, selfish, just wanted attention; Cronbach's $\alpha = .78$), and *positive/external attributions* (four items: upset by the situation, no one was helping the baby, trying to show he or she needs help; had no way to feel better; Cronbach's $\alpha = .52$). Because alpha coefficients were marginal for both minimizing attributions and positive/external attributions in the current sample, only the negative attributions subscale score was used in the analyses. A negative attributions score was calculated by averaging relevant items.

Covariates. For the analyses involving EEG data only, several potential confounds were considered, including left-handedness ($n = 12$), ever having suffered a head injury ($n = 10$), ever being unconscious for more than 10 min ($n = 5$), and prescription medication use on the day of the assessment ($n = 23$). The results of analyses, including these concurrently assessed covariates, did not differ in direction or effect size from the results without these EEG covariates included. Thus, in the interest of parsimony, analyses of EEG data without concurrently assessed covariates are presented.

The same four childhood and demographic covariates as used in previous investigations of the legacy of early caregiving experiences in the MLSRA (e.g., Raby, Roisman, Simpson, et al., 2015) were included in the current analyses in order to maintain consistency across existing research and to confirm that the obtained results are unique to maternal sensitivity. These included participant sex (1 = female, 0 = male), participant ethnicity, maternal education during childhood, and childhood socioeconomic status (SES). A majority of the sample was White/non-Hispanic, so a binary variable representing ethnicity (1 = White/non-Hispanic, 0 = otherwise) was used. Maternal education was operationalized as the number of years of education each mother had completed, averaged across information collected at 3 months prenatally; 42 months; Grades 1, 2, 3, and 6; and age 16. Childhood SES was indexed by Duncan's Socioeconomic Index, a widely used indicator of occupational ranking (Stevens & Featherman, 1981), which was rated at 42 months, 54 months, Grades 1–3, Grade 6, and age 16; ratings were averaged to create a composite of mothers' occupational status throughout childhood.

Results

Preliminary Analyses

Analyses were conducted in SPSS Version 24 (IBM Corp., 2016). Descriptive statistics and zero-order correlations among primary study variables are presented in Table 1. None of the focal variables had missing data points except for negative attributions (1.4% missing). Missing data for this variable were replaced using expectation maximization estimation. Results did not vary from those presented below when missing data were omitted from relevant analyses. The negative attributions composite was also positively skewed. A rank-order transformation (Blom, 1958) was conducted to normalize the distribution of negative attribution scores, and this transformed variable was used in analyses.

Early Sensitivity and Electrophysiological Responding to Infant Distress

A hierarchical multiple regression was conducted to determine whether early maternal sensitivity predicted change from rest in frontal EEG asymmetry to infant crying, independent of maternal sensitivity during later childhood and demographic covariates. The frontal EEG asymmetry change score from rest (baseline) to infant crying was entered as the dependent variable, with early maternal sensitivity entered as a predictor in Step 1, followed by later maternal sensitivity in Step 2, and the four demographic covariates in Step 3. As shown in Table 2, the results of Step 1 revealed that higher levels of early maternal sensitivity were related to increases in the frontal EEG asymmetry change score, $F(1, 71) = 5.11$, $p = .027$, $R^2 = .07$. This association remained small to medium in magnitude and significant when controlling for later maternal sensitivity in Step 2, which did not explain additional variance in EEG asymmetry change scores, $\Delta F(1, 70) = .03$, $p = .866$, $\Delta R^2 = <.01$. The association also held in magnitude of effect and in significance after including the four demographic covariates in the third step, $\Delta F(1, 66) = .45$, $p = .774$, $\Delta R^2 = .03$, none of which explained additional variance in change in frontal EEG asymmetry from rest to infant crying.

Because the current sample comprised both parents and nonparents, a follow-up regression analysis was conducted exploring the possibility that parental status moderated the focal result. The main effects of both early sensitivity and parental status were included in the first step, the interaction between parental status and early sensitivity was added in the second step, and later sensitivity and other demographic covariates were added in the third and fourth steps, respectively. Results showed that, although early sensitivity was still significantly associated with small- to medium-sized increases in frontal EEG asymmetry change scores ($\beta = .25$, $p = .034$), parental status did not predict changes in EEG asymmetry ($\beta = -.10$, $p = .409$), nor did the interaction between early sensitivity and parental status contribute beyond the influence of the main effects, $\Delta F(1, 71) = .59$, $p = .444$ ($\beta = .22$, $p = .444$), suggesting that the predictive significance of early sensitivity for adults' EEG responses to infant crying was similar across both parents and nonparents.

Although regression results demonstrate that experiencing greater early maternal sensitivity was related to increases from baseline in frontal EEG asymmetry during infant crying, they do not clearly indicate (a) if individuals who experienced greater early maternal sensitivity demonstrated an entirely opposite pattern of EEG response (i.e., a positive EEG change score reflecting greater relative left EEG activation) than those who experienced a lack of maternal sensitivity in early childhood (i.e., a negative value reflecting greater relative right EEG activation in this hypothetical example) or (b) if individuals who experienced greater maternal sensitivity in early life exhibited larger shifts toward a pattern of greater relative left EEG activation (i.e., increases resulting in a higher positive EEG change score) compared to those who experienced less maternal sensitivity in early life (who would have a lower positive or zero EEG change score in this example). Thus, in order to further explore the nature of the identified association between early maternal sensitivity and change in EEG asymmetry

Table 1

Zero-Order Correlations and Descriptive Statistics for Focal Variables and Demographic Covariates

Variable	1	2	3	4	5	6	7	8
1. Change in EEG from rest to infant crying	—	−.05	.26*	.06	.12	−.05	.02	.004
2. Negative attributions		—	.22†	.07	.15	.08	−.32**	−.11
3. Early maternal sensitivity			—	.30**	.43***	.31**	.16	.07
4. Later maternal sensitivity				—	.33**	.18	−.15	.17
5. Childhood maternal education (in years)					—	.49***	−.29*	−.18
6. Childhood maternal SES						—	−.14	.04
7. Participant sex							—	.08
8. Participant ethnicity								—
M	.01	.01	−.03	−.10	12.36	23.24	M = 30	W = 47
SD	.07	.95	.66	.99	1.53	1.53	F = 43	O = 26

Note. $N = 73$. Means and standard deviations are presented for all variables other than participant sex and participant ethnicity, where frequency counts are presented. For sex, 1 = female, 0 = male; For ethnicity, 1 = White/non-Hispanic, 0 = other ethnicity; SES = socioeconomic status; M = male; F = female; W = White/non-Hispanic; O = other ethnicity.
† $p = .063$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 2
Maternal Sensitivity and Demographic Covariates as Predictors of Change in Frontal EEG Asymmetry from Rest in Response to Infant Crying

Variable	*B*	*SE*	β	*p*	95% CI of *B*
1. Early sensitivity	.03	.01	.26	.027	[.003, .05]
2. Early sensitivity	.03	.01	.27	.032	[.002, .05]
Later sensitivity	−.001	.01	−.02	.866	[−.02, .02]
3. Early sensitivity	.03	.02	.30	.042	[.001, .06]
Later sensitivity	−.002	.01	−.03	.815	[−.02, .02]
Participant sex	−.01	.02	−.04	.757	[−.04, .03]
Participant ethnicity	.002	.02	.01	.931	[−.03, .04]
Maternal education	.003	.01	.08	.639	[−.01, .02]
Childhood SES	−.001	.001	−.18	.195	[−.003, .001]

Note. $N = 73$. For participant sex, 0 = male, 1 = female; For ethnicity, 0 = other ethnicity, 1 = White/non-Hispanic; SES = socioeconomic status.

from rest to cry, a mean-split early maternal sensitivity variable was created, and descriptive statistics for change in frontal EEG asymmetry were examined across individuals who had experienced either below- or above-average levels of early maternal sensitivity. Results revealed that adults who had experienced early maternal sensitivity that was lower than the sample mean ($n = 38$) showed no change in EEG asymmetry from rest to infant crying, evidenced by a zero mean change in EEG asymmetry score ($M = 0$, $SD = .06$), whereas adults who experienced early maternal sensitivity that was above the sample mean ($n = 35$) demonstrated greater relative left frontal EEG activation from rest to infant crying, evidenced by a positive mean change in EEG asymmetry score ($M = .02$, $SD = .08$).

Cognitive Appraisals of Infant Distress

A separate hierarchical regression was conducted to determine whether experiencing higher levels of early maternal sensitivity predicted making fewer negative attributions for infant crying. Early maternal sensitivity was again entered as a predictor in Step 1, followed by later maternal sensitivity in Step 2, and the childhood demographic covariates in the third step. As described in Table 3, the results of the first step revealed a negative association (trend level) between maternal sensitivity during early childhood and making more negative attributions for infant crying at age 39 years, $F(1, 71) = 3.57$, $p = .063$, $R^2 = .05$. The inclusion of later maternal sensitivity in the second step did not explain additional variance in negative attributions, $\Delta F(1, 70) = 1.55$, $p = .215$, $\Delta R^2 = .02$, and the negative association between early maternal sensitivity and negative attributions for infant crying remained small to medium in effect size in this step (and became significant); maternal sensitivity in later childhood did not predict negative attributions. Adding the four demographic covariates in the final step did not explain additional variance, $\Delta F(1, 66) = 1.93$, $p = .115$, $\Delta R^2 = .10$, and the association between early maternal sensitivity and negative attributions had a similar small to medium effect size and remained significant when covariates were included.

Again, given our combined sample of parents and nonparents, a follow-up regression analysis explored the possibility for moderation by parental status. Results showed a main effect of early sensitivity ($\beta = -.24$, $p = .039$) but not parental status ($\beta = -.18$, $p = .129$) in Step 1. However, the inclusion of the interaction between early sensitivity and parental status accounted for additional variance in negative attributions, $\Delta F(1, 69) = 4.65$, $p = .035$ ($\beta = -.58$, $p = .035$), suggesting that parental status moderated the association between early sensitivity and negative attributions for infant crying. Further examination of this interaction (see Figure 1) showed a moderate and significant effect of experiencing greater early sensitivity on making fewer negative attributions for infant crying in parents ($\beta = -.38$, $p = .011$), while the corresponding association for nonparents was small in magnitude and nonsignificant ($\beta = .22$, $p = .464$).

Discussion

This investigation is the first to examine whether individuals' own early childhood experiences with primary caregivers predict their electrophysiological responding to and their cognitive appraisals of infant distress in adulthood. Our findings show that experiencing greater maternal sensitivity during the first 3½ years of life is associated with patterns of change in EEG asymmetry, signifying an approach-oriented response to infant distress (i.e., change toward greater relative left [vs. right] frontal EEG activation from rest to infant crying), regardless of parental status, and with making fewer negative appraisals of infant crying more than three decades later as adults, particularly for individuals who were parents. Both sets of results held when maternal sensitivity in later childhood and potential demographic and early life confounds were statistically controlled. These findings extend our knowledge of the nature of the enduring association between adults' own experiences of sensitive caregiving during early childhood and their functional capacity within salient social developmental contexts in adulthood (see Fraley et al., 2013; Raby, Roisman, Fraley, et al., 2015). In particular, the results of the current study suggest that both electrophysiological responding to and cognitive appraisals of others' behavior are possible explanatory mechanisms for the enduring associations observed in the MLSRA and elsewhere between early caregiving experiences and social competence well into the adult years.

Individuals who experienced more sensitive care in early childhood exhibited an approach-oriented response to infant distress,

Table 3
Maternal Sensitivity and Demographic Covariates as Predictors of Negative/Internal Cognitive Attributions for Infant Crying

Variable	*B*	*SE*	β	*p*	95% CI of *B*
1. Early sensitivity	−.32	.17	−.22	.063	[−.65, .02]
2. Early sensitivity	−.38	.17	−.27	.032	[−.73, −.03]
Later sensitivity	.15	.12	.15	.215	[−.09, .38]
3. Early sensitivity	−.41	.20	−.29	.040	[−.81, −.02]
Later sensitivity	.08	.12	.08	.540	[−.17, .32]
Participant sex	−.40	.24	−.21	.106	[−.88, .09]
Participant ethnicity	−.11	.24	−.06	.639	[−.59, .36]
Maternal education	.09	.10	.15	.337	[−.10, .29]
Childhood SES	.01	.01	.05	.681	[−.02, .03]

Note. $N = 73$. For participant sex, 0 = male, 1 = female; For ethnicity, 0 = other ethnicity, 1 = White/non-Hispanic; SES = socioeconomic status.

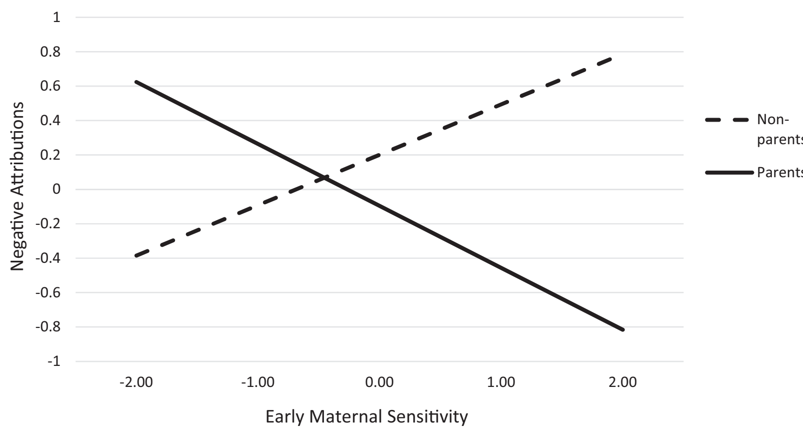

Figure 1. Parental status as a moderator of the association between early maternal sensitivity and negative attributions for infant crying. Early maternal sensitivity and negative attributions were standardized to illustrate the interaction in the figure. As noted in text, the negative association between early sensitivity and negative attributions for infant crying among parents was $\beta = -.38$, $p = .011$, whereas the corresponding association for nonparents was $\beta = .22$, $p = .464$.

evidenced by change toward greater relative left frontal EEG activation from rest when hearing infant crying; in contrast, individuals who experienced low maternal sensitivity in early life demonstrated no change in EEG asymmetry from rest in response to infant crying. These results suggest that experiencing more sensitive care early in childhood may promote electrophysiological responses in the face of distressing caregiving contexts that reflect one's ability to organize an adaptive response to situational demands (i.e., one that would facilitate a response to stop the infant's crying; see Coan, Allen, & McKnight, 2006, for a discussion of the capability model of individual differences in EEG asymmetry). Conversely, a lack of sensitive care in early life may promote a limited capacity for organizing this type of response. One possible interpretation of these findings is that the approach-oriented EEG response displayed by individuals who had experienced higher levels of early maternal sensitivity in this sample may facilitate their own likelihood of providing care to a crying infant, which reflects greater competency within the social domain of parenting.

An empirical link between this pattern of left frontal EEG asymmetry and caregiving behavior has yet to be established. Although we were unable to directly test this hypothesis in the current study, it is nonetheless theoretically consistent with existing research regarding longitudinal associations between childhood experiences of maternal sensitivity and providing supportive caregiving behavior as parents (Belsky et al., 2012; Brook et al., 2012; Raby, Lawler, et al., 2015). Alternatively, greater relative left frontal EEG activation may reflect an emotional response of anger or frustration, which may also promote approach-oriented behavior. This pattern of frontal EEG asymmetry has been identified previously in adults during (nonparenting-related) anger-inducing contexts, particularly when an approach-oriented response was perceived as being likely to resolve the anger-inducing event (e.g., Harmon-Jones & Sigelman, 2001; Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003). Regardless, our findings extend existing research linking maternal sensitivity with left frontal EEG asymmetry in infancy and early childhood (Hane & Fox, 2006; Hane et al., 2010) by demonstrating the same association well into adulthood, in response to a specific caregiving-related stimulus, and signal the need for additional research to replicate our findings and corroborate these possible interpretations.

Of note, experiences of greater early maternal sensitivity were associated with the opposite pattern of EEG responses to infant distress than identified in previous research linking these responses to caregiving-related factors (Groh et al., 2015; Killeen & Teti, 2012). Variation in these findings may be accounted for by the fact that the current study is the first to examine *longitudinal* associations between early caregiving experiences and changes in EEG asymmetry in response to infant distress; two additional explanations can be suggested.

First, the current sample included both males and females, as well as both parents and nonparents, while both prior studies featured only mothers. That said, parental status did not moderate the association between early sensitivity and EEG response in this study, which limits the likelihood of including both parents and nonparents in the current sample as a primary explanation for the variation in results. Moreover, sex was included as a covariate in analyses, and patterns of change in EEG asymmetry in response to infant crying were not related to sex. Second, the two previous investigations included samples of mothers of infants or very young children, while parents in the current sample were not restricted to having children within this early age range. Thus, variation in EEG results may actually reflect differences in the salience of infant crying across samples. For instance, mothers of infants and young children may be more likely to have an empathically matched response (reflected by the withdrawal-oriented response reflected by greater relative right EEG activation; see Groh et al., 2015, and Killeen & Teti, 2012, for a discussion) than were parents with children of varying ages (and nonparents) in the current sample because they are more salient to their concurrent parenting experience. Indeed, prior research has shown that, although exposure to negative emotional stimuli such as sadness typically evokes change to greater right (vs. left) frontal EEG activation in most research regarding EEG asymmetries, the *op-*

posite pattern of greater left (vs. right) EEG activation has been observed if the individual does not experience concomitant emotion (see Coan & Allen, 2003; see also Fox & Davidson, 1988). Thus, perhaps infant crying was more likely to elicit concomitant feelings of sadness in the mothers of infants and young children comprising the samples in prior research compared to individuals in the current sample, many of whom were not currently caring for an infant or young child. This variation in the salience of infant distress signals and experiences of concomitant emotion may thus account for variation in the patterns of change in EEG asymmetry observed in current and past research.

With respect to cognitive appraisals for infant crying, adults (especially those who identified as parents) who had experienced higher levels of maternal sensitivity during early childhood were less likely to make negative appraisals (attributions) for infant crying. This finding offers prospective evidence aligned with previous research using proxy measures of mothers' childhood experiences (Leerkes & Siepak, 2006; Leerkes et al., 2015). Adult parents who make fewer negative appraisals may be better equipped to provide more sensitive responses to a distressed child because they have the cognitive awareness and accompanying empathy that a child's distress deserves a supportive response instead of being attributed to a dispositional or selfish source. Further, our findings suggest that parents may be more likely than nonparents to draw on early experiences with their own sensitive (or insensitive) caregivers as a model by which to support their appraisals of infant crying. The results of the electrophysiological responses and cognitive appraisals in this study are consistent with theoretical views that experiencing higher quality relationships with caregivers during early childhood promotes the development of adaptive regulatory responses to and cognitive appraisals of both one's own and others' behaviors in the salient social contexts of adulthood (see Bowlby, 1988).

These findings provide several contributions to the existing literature. First, they add novel prospective evidence regarding the interpersonal antecedents of adults' physiological and cognitive responding to infant distress cues (Ablow, Marks, Feldman, & Huffman, 2013; Groh & Roisman, 2009; Groh et al., 2015; Leerkes & Siepak, 2006; Leerkes et al., 2015; Riem et al., 2012; Schoenmaker et al., 2015) and build upon recent research emphasizing the predictive significance of maternal sensitivity in the MLSRA (e.g., Raby, Lawler, et al., 2015; Raby, Roisman, Simpson, et al., 2015; Waters et al., 2017). More broadly, these results contribute to a growing body of evidence (see Fraley et al., 2013; Raby, Roisman, Fraley, et al., 2015) on the lasting significance of experiencing *early* supportive caregiving across the life span by highlighting possible explanatory mechanisms that may underlie these enduring associations.

Nonetheless, these novel findings need replication in other, ideally larger, longitudinal samples given the modest sample size of the MLSRA as well as its higher risk nature. Additional research testing whether electrophysiological responding and cognitive appraisals mediate longitudinal associations between early caregiving experiences and demonstrated parenting behavior in adulthood (or adults' behavior more broadly in other important adult social contexts) should also be a high priority. Testing of mediational models using the current sample was not possible given its prohibitively small size and the temporal sequencing of the current assessment and those involving parenting behavior in the MLSRA. Moreover, researchers should aim to replicate the current results when considering parents' reactions to their own offspring; the current investigation examined responses to a hypothetical infant's distress, but it would be important to note how associations between experiences with early maternal sensitivity and EEG responses or cognitive attributions may vary when applied to one's own child. Researchers should further consider the impact of whether an individual is currently parenting an infant or young child, as it is possible that parents for whom infant distress signals (crying) are concurrently relevant may demonstrate a different EEG response pattern than those whose children are older, for whom infant distress is a less salient social cue. We unfortunately did not assess current offspring age at the time of EEG and attributions assessment, which is a limitation of this investigation. Additional research should also determine whether the current pattern of results extends to other important adult social contexts, such as romantic relationships or relationships with one's aging parents. Additional inquiry along these lines could provide important new knowledge about how the quality of individuals' experiences with primary caregivers in early in life continue to shape their capacity for effective social functioning at midlife.

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