WILEY

Brain and Behavior
Open Access

ORIGINAL ARTICLE OPEN ACCESS

Associations of Prenatal Social Support in Adolescent Mothers With Measures of Social-Emotional Development in Their Young Children

Cristin M. Holland[1] | Huili Sun[2] | Raimundo X. Rodriguez[2] | Margaret Bennett[1] | Bin Cheng[3] | Bradley S. Peterson[4,5] | Dustin Scheinost[2,6] | Marisa N. Spann[1,7]

[1]Vagelos College of Physicians and Surgeons, Columbia University, New York, New York, USA | [2]Yale University, New Haven, Connecticut, USA | [3]Mailman School of Public Health, Columbia University, New York, New York, USA | [4]Keck School of Medicine, University of Southern California, Los Angeles, California, USA | [5]Children's Hospital Los Angeles, Los Angeles, California, USA | [6]Yale School of Medicine, New Haven, Connecticut, USA | [7]New York State Psychiatric Institute, New York, New York, USA

Correspondence: Marisa N. Spann (mns2125@cumc.columbia.edu)

Received: 13 August 2025 | **Revised:** 13 October 2025 | **Accepted:** 25 October 2025

Keywords: attachment | infant | language | maternal sensitivity | prenatal | social support

ABSTRACT

Objective: Social environments are essential for supporting social-emotional development in children. However, little consideration has been given to social environments children may be exposed to prior to birth and how this may affect social behavior for both generations postnatally. As such, this study considered the impact of maternal social support during pregnancy on infant and maternal social behaviors in very early childhood.

Methods: Pregnant adolescents from 2009–2012 evaluated their social support and participated in maternal-infant interactions at 4 and 14 months of age to assess maternal sensitivity and child attachment. Social skills and language development of infants were evaluated at 4 months of age. A subset of infants underwent MRI to assess functional connectivity of a social brain network. Path analyses were conducted to determine associations among prenatal maternal social support, 4-month maternal sensitivity, 4-month infant language and social development, and 14-month child attachment.

Results: We detected significant associations of prenatal social support satisfaction with 4-month infant social development, and with maternal sensitivity and infant language development at 4 months. No maternal or infant factors were associated with attachment at 14 months. Exploratory path analysis included neonate social brain network connectivity. No significant associations were demonstrated between maternal or infant factors and neonate brain connectivity.

Conclusion: This study underscores the importance of maternal perceived satisfaction with social support during pregnancy and sensitivity in infancy for child social and language development.

1 | Introduction

Secure attachment in early years promotes self-reliance, emotion regulation, and social competence in childhood and through adulthood (Cooke et al. 2019; Sroufe 2005; Sroufe et al. 2005). Foundations for social and emotional developmental trajectories leading to secure attachment are laid through early experiences that shape development in combination with genetics (Boyce et al. 2021). These experiences, including social and caregiving environments, can begin in utero. Recently, higher levels of social support were found to be a protective factor for pregnant women who reported depression and anxiety (Filippetti et al. 2022;

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2025 The Author(s). *Brain and Behavior* published by Wiley Periodicals LLC.

Modde Epstein et al. 2024) and can ensure greater attachment to their fetus (Ponti et al. 2021). Social support may be an important factor in how bonding and interactive behavior with offspring may develop. A few studies identified that prenatal social support can buffer the effect of negative maternal mental health, including anxiety, depression, and stress on offspring's predictable social engagement during infancy (Takács et al. 2021) and attachment during toddler age (Jacobson and Frye 1991). However, research on social support during pregnancy and its role in the social-emotional development of the child is still limited.

A more extensive literature exists demonstrating that, postnatally, infant social-emotional development is influenced by caregiving behavior. Specifically, maternal sensitivity, the ability to detect and respond to infant cues, has been connected to social development and child attachment style. Caregiving behaviors that were more sensitive to the child's interest and did not control or restrict the child, predicted greater social development (Landry et al. 1997; Ziv et al. 2018). Higher sensitivity from mothers during infancy was positively associated with attachment at toddler and preschool ages (Bigelow et al. 2010; Braungart-Rieker et al. 2014; Ziv et al. 2000), and may be a mechanism through which infant attachment security is formed when considering maternal embodied mentalizing, a parent's understanding of the thoughts, feelings, and attitudes of a child (Gagné et al. 2021). Additionally, higher and positive maternal responsiveness, which is also used to describe how mothers react to their children during dyadic interactions, was associated with greater social, emotional, and communication skills, as well as overall growth of social-emotional competence (Bornstein and Manian 2013; Landry et al. 2006; Merz et al. 2015; Pearson et al. 2011).

Similar to social support, maternal sensitivity and responsiveness have been shown to buffer adverse experiences on offspring social-emotional development (Wurster et al. 2020). For example, maternal sensitivity has been shown to moderate the relationship between maternal prenatal anxiety and offspring social-emotional behaviors, including temperamental reactivity and externalizing problems from infancy through toddler age (Frigerio and Nazzari 2021; Grant et al. 2010; Thomas et al. 2017). While prior research suggests that maternal sensitivity and responsiveness can lead to better social development in offspring, how prenatal social engagement, which can support a caregiving environment, may interact to affect developing social-emotional processes in offspring is unclear.

1.1 | Social Brain Network

Social brain systems emerge in infancy, and can be important to both acquisition of social competencies and trajectories of social-emotional development (Grossmann and Johnson 2007; Ilyka et al. 2021; Mcpartland and Pelphrey 2012). Additionally, a plethora of research has demonstrated the importance of maternal caregiving behavior, such as sensitivity, for neurocognitive development, particularly related to social-emotional competence (Curley and Champagne 2016). For example, children with larger neonate total brain volume demonstrated better cognitive outcomes when exposed to higher maternal sensitivity in infancy, and poorer cognitive outcomes when exposed to lower maternal sensitivity, reflecting differential susceptibility to maternal sensitivity at 6 months in relation to future cognitive development (Nolvi et al. 2020). At 6 months of age, maternal sensitivity has been positively associated with functional connectivity between the hippocampus and other brain areas critical to emotional regulation and socio-emotional functioning (Rifkin-Graboi et al. 2015), and lower maternal sensitivity in early infancy predicted development of neuroanatomy related to learning and stress regulation in childhood, such as larger amygdalae in males six years of age (Lee et al. 2019). Fewer studies have considered prenatal maternal social environments and offspring neurodevelopment. One study demonstrated that partner status of mothers moderated the relationship between socioeconomic status and neonate brain volumes, in that infants with mothers with lower SES and a partner had greater brain volumes in areas such as the middle temporal and occipital, inferior frontal and medial superior frontal regions in both hemispheres, and the anterior cingulate of the left hemisphere compared to infants whose mothers did not have a partner (Spann et al. 2020). Similar patterns were seen in pregnant women with higher SES who did not have a partner compared to those with a partner. Further research is needed to understand how both prenatal and postnatal social and caregiving environments and behaviors interact with offspring neurodevelopment across infancy.

1.2 | The Current Study

There remains a gap in understanding how prenatal social support may shape postnatal maternal caregiving behavior and bonding during dyadic interactions with their infants, and in turn how this supports social-emotional development of the offspring. The aim of this study was to assess associations between social-emotional behaviors in both mothers and infants longitudinally, across the prenatal period through 14 months postnatal. The associations between prenatal social support, maternal sensitivity at 4 months, infant social skill and language development at 4 months, and attachment security at 14 months of age are considered through multiple pathways to assess the complex interrelationships that may exist between these social variables. We hypothesized that mothers who endorsed higher satisfaction of social support during pregnancy, as well as those who demonstrated higher sensitivity in caregiving behavior postnatally, would have infants who demonstrated increased social development at 4 months of age, which would subsequently lead to a more secure attachment at 14 months.

2 | Methods

2.1 | Participants

Pregnant individuals ages 14 to 21 years old were recruited through the Department of Obstetrics and Gynecology at Columbia University Irving Medical Center (CUIMC), Weill Cornell Medical College, and flyers posted throughout the CUIMC area as part of a prospective study examining pregnancy behaviors in adolescents and young adults and their infant outcomes through 14 months of age from 2009 to 2012. Pregnant individuals had no major health problems at the time of recruitment and received routine prenatal care. Pregnant individuals

were excluded if they used recreational drugs, tobacco, alcohol, or medications that affect cardiovascular functions, or lacked fluency in English. Parental consent and adolescent assent were obtained for pregnant adolescents to participate in the study. Pregnant individuals aged 18 and older provided written informed consent for themselves, and mothers provided written informed consent for their infants to participate in the study. All study procedures were approved by the New York State Psychiatric Institute Institutional Review Board.

2.2 | Measures

2.2.1 | Prenatal Social Support

The Social Support Questionnaire (SSQ) was completed during the second or third trimester of pregnancy. The SSQ is a 27-item self-report questionnaire that assesses the quality of social support and perceived satisfaction with that support. Each of the 27 questions is broken into a two-part answer: The first part asks participants to list all the people that fit the description of the question, while the second part asks participants to indicate how satisfied they are, in general, with the people they listed in part 1. For part 1, the number of individuals reported across each question is totaled. An individual person is only counted once even if they are reported for more than one question. In part 2, participants rate their satisfaction on a scale from 1 (very dissatisfied) to 6 (very satisfied). To compute the total satisfaction score, scores are summed and then divided by the total number of items, resulting in a total average score ranging from 1 to 6. Total average satisfaction of social support scores and total number of social support persons were used in analyses. There were 91 maternal participants who had corresponding follow-up data and were used in analyses.

2.2.2 | Neonate Social Brain Network

2.2.2.1 | Imaging Procedures. A subset of infants was imaged within the first 6 weeks of postnatal life (postmenstrual age [PMA] ≤ 46 weeks). Infants were fed, swaddled, and acclimated to the scanning environment and scanner noise by listening to a tape recording of the scanner sounds played prior to each pulse sequence. Before the start of each sequence, infants were given time to fall asleep without using sedatives while lying on the scanner bed. Infants wore foam and wax ear plugs and ear shields to dampen scanner noise (Natus Medical Inc., San Carlos, CA). MRI-compatible electrocardiogram (EKG) leads were placed on the infant's chest, and a pulse oximetry sensor was placed on the infant's toe. Heart rate and oxygen saturation were continuously monitored during the scan (InVivo Research, Orlando, FL).

2.2.2.2 | Imaging Parameters. Images were obtained using a 3 Tesla General Electric (GE) Signa MRI scanner (Milwaukee, Wisconsin) and an 8-channel head coil. High resolution anatomical T2-weighted images were acquired using a 2D, multiple-shot, fast spin echo pulse sequence that employed periodically rotated overlapping parallel lines with enhanced reconstruction (PROPELLER) to reduce motion artifacts in reconstructed MR images [18]: repetition time (TR) = 10,000 ms; echo time (TE) = 130 ms; echo train length (ETL) = 32; matrix size = 192 × 192; field of view (FOV) = 190 × 190 mm; phase FOV = 100%; slice thickness = 1.0 mm; number of excitations (NEX) = 2. The spatial resolution of the T2-weighted images was 1 mm^3. Functional images were acquired using a standard echo-planar imaging sequence: TR = 2200 ms; TE = 30 ms; matrix size = 64 × 64; FOV = 190 × 190 mm; phase FOV = 100%; slice thickness = 5.0 mm, contiguous; number of slices = 24; bandwidth = 7812.5 Hz. Although the number of runs acquired varied per participant due to compliance, a median of 22 min 26.4 s of usable data across all runs was obtained for each infant.

2.2.2.3 | Common Space Registration. First, anatomical images were skull stripped using FSL (https://fsl.fmrib.ox.ac.uk/fsl/) and any remaining non-brain tissue was manually removed. All further analyses were performed using BioImage Suite (Joshi et al. 2011) unless otherwise specified. Anatomical images were linearly aligned to a single infant anatomical scan from an independent study (Scheinost et al. 2016) using a 12 parameter affine registration by maximizing the normalized mutual information between images. Next, anatomical images were non-linearly registered to an evolving group average template in an iterative fashion using a previously validated algorithm (Scheinost et al. 2017). This algorithm iterates between estimating a local transformation to align individual brains to a group average template and creating a new group average template based on the previous transformations. The local transformation was modeled using a free-form deformation (FFD) parameterized by cubic B-splines. This transformation deforms an object by manipulating an underlying mesh of control points. The deformation for voxels in between control points was interpolated using B-splines to form a continuous deformation field. Positions of control points were optimized using a conjugate gradient descent to maximize the normalized mutual information between the template and individual brains. After each iteration, the quality of the local transformation was improved by increasing the number of control points and decreasing the spacing between control points to capture a more precise alignment. A total of 5 iterations were performed with decreasing control point spacings of 15 mm, 10 mm, 5 mm, 2.5 mm, and 1.25 mm. To help prevent local minimums during optimization, a multi-resolution approach was used with three resolution levels at each iteration. Finally, functional images were rigidly aligned to the anatomical images.

All transformation pairs were calculated independently and combined into a single transform, warping the single participant results into common space. This single transformation allows the individual participant images to be transformed to the common space with only one transformation, thereby reducing interpolation error.

2.2.2.4 | Connectivity Processing. Motion correction was performed using SPM8 (http://www.fil.ion.ucl.ac.uk/spm/). Images were warped into 3 mm^3 common space using the non-linear transformation and cubic interpolation. Next, images were iteratively smoothed until the smoothness of an image had a full-width half maximum of approximately 8 mm using AFNI's 3dBlurToFWHM (http://afni.nimh.nih.gov/afni/). Iteratively smoothing to a set smoothness reduces the smoothing applied to the image (which helps resolve smaller structures like the amygdala) and motion-related confounds. Several covariates of

no interest were regressed from the data, including linear and quadratic drifts, mean cerebral-spinal-fluid (CSF) signal, mean white-matter signal, and mean gray matter signal. For additional control of possible motion-related confounds, a 24-parameter motion model (including six rigid-body motion parameters, six temporal derivatives, and these terms squared) was regressed from the data. The functional data were temporally smoothed with a Gaussian filter (approximate cutoff frequency = 0.12 Hz).

2.2.2.5 | Motion Analysis. As motion and amount of data for analysis affect functional connectivity measures (Noble et al. 2017; Van Dijk et al. 2012), we employed a strict inclusion criterion that participants had at least 2 runs of data with an average frame-to-frame motion of less than 0.1 mm. For infants with more than 2 runs with good movement, we selected the 2 runs with the least frame-to-frame motion. We detected no significant correlations between motion and maternal experience of discrimination and acculturation (r's < 0.15, p's > 0.4). Further, as described above, we employed global signal regression, a 24-parameter motion model regression, and uniform smoothing to minimize motion confounds not accounted for by our inclusion criteria.

2.2.2.6 | Seed Connectivity. After preprocessing, we assessed whole-brain seed to voxel connectivity across five bihemispheric brain regions associated with the social brain network. Brain regions included the medial prefrontal cortex, inferior frontal gyrus, superior temporal lobe, temporal pole, and the posterior cingulate cortex (Figure S1). These areas were chosen based on their role in social behavior. The medial prefrontal cortex circuits have been implicated in social cognition, such as social decision-making and affective processes (Gangopadhyay et al. 2021; Gordon et al. 2011; Huang et al. 2020). The inferior frontal gyrus plays a role in social touch (Peled-Avron et al. 2019). The superior temporal lobe and temporal pole, particularly the superior temporal sulcus, support social cognition and perception, as well as face perception, a socially important process (Barton 2022; Pelphrey and Carter 2008; Smith et al. 2023). The posterior cingulate cortex may play a role in social-emotional information processing (Leung and Lau 2020), and is important for regulation of attention between internal and external thoughts and self-referential thought, both of which can impact social behavior (Brewer et al. 2013; Leech et al. 2011; Leung and Lau 2020). Additionally, these areas have all been implicated in a network for theory of mind, or mentalizing, a crucial skill for social cognition (Poulin-Dubois 2020; Yang et al. 2015). The time course of the reference regions in each participant was then computed as the average time course across all voxels in the seed regions. These time courses were correlated with the time course for every seed to create r-values, reflecting seed-to-seed connectivity. These r-values were transformed to z-values using Fisher's transform and averaged, yielding a single value representing the strength of connectivity in the social brain for each participant. A total of 43 neonates had fMRI data used in analyses.

2.2.3 | Maternal Sensitivity

Maternal sensitivity was observationally coded from videotapes of mother-child free play when the child was 4 months of age using well-validated coding schemes for maternal warmth and responsiveness. Global ratings of warmth and responsiveness used a 5-point scale: 1 = almost never, 2 = some of the time, 3 = half the time, 4 = most of the time, and 5 = almost always and were rated at the end of the video. Ratings of warmth were based on evidence from indicators like positive affect, praise, encouragement, physical affection, and acceptance of the child. Ratings of responsiveness were based on actions of the mother such as consistent involvement, timely and appropriate responses to the child's signals, and following the child's lead. The rating scales were adapted from well-validated scales widely used in previous research, and were chosen due to their relevance to the construct of sensitivity (e.g., Landry et al. 2001, 2006; Merz et al. 2015). Ratings demonstrated good internal consistency across ages with Cronbach's alphas between .81 and .91 and prior interrater reliability within good ranges (r = 0.74) (Hallgren 2012; Landry et al. 2001, 2006). Consensus codes of warmth and responsiveness were totaled and used in analyses. A total of 72 maternal participants had warmth + responsiveness total scores that were used in analyses.

2.2.4 | Infant Social Development

The Bayley Scales of Infant and Toddler Development, Third Edition (Bayley, 2006; BSID-III) was administered at 4 months of age. The BSID-III is a standardized assessment of developmental functioning in early childhood between 1 and 42 months. It assesses five domains of development: cognition, language, motor, adaptive behavior, and social-emotional.

2.2.4.1 | Language Development. The language component of the BSID-III has both a receptive and expressive language scale. Scores from the expressive and receptive language scores are totaled to create a language sum score. This sum score is transformed into a standardized language composite score. This composite score for language was then used in analyses. A total of 83 infant participants had language composite scores at 4 months of age that were used in analyses.

2.2.4.2 | Social Skills Development. The adaptive behavior caregiver-report questionnaire assesses the child's functional skills and ability to adapt to demands of daily living activities in multiple domains, including social skills. The social skills scaled score from this adaptive behavior questionnaire was used. Social skills scaled scores range from 1 to 19, with 8-12 considered average. A total of 72 infant participants had social skills scaled scores from this questionnaire at 4 months of age used in analyses.

2.2.5 | Infant Attachment Security

The Strange Situation is a standardized procedure developed to observe attachment security in children 9 to 24 months within the context of caregiver relationships. It takes approximately 30 min to administer and was videoed when the children were 14 months of age. Trained coders reviewed the videos of the Strange Situation and classified the child into one of four patterns of attachment security: (A) secure, (B) insecure avoidant, or (C) insecure resistant. Children are rated/considered on interactive behaviors of proximity- and contact-seeking, contact-maintaining, resistance,

and avoidance. These interactive behaviors are used to determine attachment security classification. A consensus for classification of attachment security pattern was reached between research assistants, and those consensus classifications were used for analyses. For our analyses, insecure avoidant and insecure resistant classifications were combined into one insecure group. A total of 56 infant participants had usable attachment classification coding for analyses.

2.3 | Statistical Analyses

Descriptive statistics were conducted in SPSS 29.0 (IBM). We also conducted correlations, t-tests, and one-way analysis of covariance between demographic variables and maternal prenatal social support, 4 month maternal sensitivity, and 4 month infant social skill and language development to determine any covariates.

Using MPlus 8.4 (Methuen and Methuen), we then used path analysis with maximum likelihood to account for missing data to assess the direct effects of prenatal social support on maternal sensitivity (warmth + responsiveness), infant social development (social skills and language) at 4 months, and infant attachment security classification at 14 months. Direct effects between maternal sensitivity and infant language and social development, as well as maternal sensitivity, infant language development, and infant social skill development on attachment security classification at 14 months, were also tested. Additionally, this model tested indirect effects for (1) the concurrent associations of maternal sensitivity at 4 months with prenatal social support and infant social skill development at 4 months, and (2) the concurrent associations of maternal sensitivity with prenatal social support and infant language development at 4 months. Maternal perceived satisfaction with social support and the number of support persons given during the prenatal period were tested in separate models.

An exploratory path analysis was conducted to examine the influence of prenatal social support on neonate social brain network connectivity and neonate social brain network connectivity effects on maternal sensitivity and infant social-emotional development at 4 months. Direct effects of prenatal social support and neonate social brain network connectivity, maternal sensitivity, and infant language and social skill development were tested, as were direct effects between neonate social brain network connectivity and maternal sensitivity, and infant social skill and language development.

3 | Results

3.1 | Descriptive Statistics

Table 1 displays demographic information for both mothers and infants. The mean age of pregnant individuals was 17.840 (SD = 1.259) years. The sample was a majority Hispanic/Latino. A total of 102 infants (male = 58, female = 44) were included in this study. Table 2 reports descriptive statistics for maternal and infant social variables prenatally to 14 months.

Bivariate associations were conducted between maternal demographic variables (e.g., maternal age) and independent and dependent variables. These variables included prenatal social support (satisfaction and number of persons), 4 month maternal sensitivity, and 4 month infant social development (social skills and language). There were no significant associations or differences found, which are reported in Table 3.

3.2 | Satisfaction of Prenatal Social Support Models

The model (Figure 1) indicated a good fit ($X^2 = 0.001$, $p = 0.970$; RMSEA < 0.001; CFI = 1.000; TLI = 1.000; SRMR = 0.001). Small to medium direct effects were found for maternal prenatal social support satisfaction predicting infant social skills at 4 months of age ($\beta = 0.231$, $p = 0.015$) and maternal sensitivity (warmth + responsiveness) on infant language scaled scores at 4 months of age ($\beta = -0.287$, $p = 0.015$). There were no significant indirect effects of maternal sensitivity at 4 months on the relationship between prenatal social support and infant social skills or infant language development in this model.

3.3 | Number of Prenatal Social Support Persons Model

A model (Figure 2) testing the prenatal number of support persons with infant social skill and language development and maternal sensitivity (warmth + responsiveness) at 4 months was conducted. This model indicated only small to medium direct effects of 4 month maternal sensitivity on 4 month language development ($\beta = -0.277$, $p = 0.019$), and continued to indicate good fit ($X^2 = 0.249$, $p = 0.618$; RMSEA < 0.001; CFI = 1.000; TLI = 1.000; SRMR = 0.014). No indirect effects of maternal sensitivity were observed.

3.4 | Exploratory Analyses With Social Brain Connectivity

As there were no significant associations of any variables with attachment classification at 14 month, this was removed from the social behavior model for exploratory testing (Figure 3). Direct and indirect effects for the mediation of social brain network connectivity on the relationship between prenatal social support satisfaction and infant social skill development at 4 months were tested. This model did not indicate a good fit ($X^2 = 0.000$, $p < 0.001$), but continued to show direct effects of prenatal satisfaction of social support on 4 month infant social skill development and maternal sensitivity on infant language development at 4-months. No other direct or indirect effects were significant.

4 | Discussion

This study investigated associations between prenatal social support of the pregnant adolescent and maternal sensitivity and infant social-emotional development, social skills, and language at 4 months postnatal, and child attachment security at 14 months

TABLE 1 | Maternal and infant demographic information.

Variable	Mean (SD) / N (%)
Maternal	
Age, yrs (n = 321)	17.840 (1.259)
Ethnicity (n = 321)	
Hispanic/latino	281 (87.50)
Not hispanic/latino	40 (12.50)
Primary language	
English	215 (68.50)
Spanish	97 (30.90)
Other	2 (0.60)
Household income (n = 277)	
$0–$15,000	122 (44.00)
$16,000–$25,000	96 (34.70)
$26,000–$50,000	46 (16.60)
≥ $51,000	13 (4.70)
Education level (n = 318)	
≤ 12th grade	184 (57.86)
General education/high school diploma	116 (36.48)
Associates degree	2 (0.63)
Other	16 (5.03)
Infant	
Sex (n = 102)	
Male	58 (56.86)
Female	44 (43.13)
Postmenstrual age at Scan, wk (n = 45)	42.46 (1.71)
Gestational age, wk (n = 101)	39.29 (1.38)
Birth weight, g (n = 98)	3177.38 (503.93)
Type of birth (n = 89)	
Vaginal	72 (80.90)
Cesarean section	17 (19.10)

of age. Additionally, associations of maternal and infant social-emotional factors with neonate social brain network functional connectivity were explored. Overall, prenatal social support was associated with infant social skill development, and maternal sensitivity was associated with language development of the infant at 4 months of age.

4.1 | Importance of Prenatal Social Support

Mothers who had higher satisfaction with their prenatal social support had infants that demonstrated higher levels of social skills at 4 months of age, while those mothers with more people in their support network did not. Additionally, the perceived quality of the social support received during pregnancy also appears more important to infant social development than how large or small a support network is. Perception of more satisfaction with current social support may provide the developing offspring with a more positive caregiving environment from the mother and others in utero and can be important to early prenatal bonding. For example, high or medium maternal social support can mitigate the relationship between an anxious romantic attachment and lower prenatal attachment (Ponti et al. 2021). Mothers who have good prenatal social support may continue to have this support after birth, and their newborns may be exposed to social situations and social dynamics more frequently. This exposure may provide opportunities for learning and practicing social skills within a larger group of people. These interactions would allow infants the opportunity to advance their social skills through increasingly fine-tuned mutual adjustments within dyadic interactions that would result in improved prediction of the social world (Hoehl and Bertenthal 2021), and result in higher social skills in early infancy.

A lack of perceived support during pregnancy could have detrimental effects on mental health during pregnancy. Indeed,

TABLE 2 | Maternal and infant social variable descriptive statistics.

Variable	Mean (SD)
Maternal	
Prenatal	
Social support satisfaction (n = 294)	5.547 (0.688)
Number of social support persons (n = 294)	26.230 (3.088)
4-month	
Warmth (n = 75)	3.293 (1.112)
Responsiveness (n = 75)	3.347 (1.020)
Sensitivity (warmth + responsiveness) (n = 75)	6.640 (1.908)
Infant	
Neonate	
Social brain network connectivity (n = 45)	0.093 (0.0419)
4-month	
Social skill development (n = 75)	11.960 (2.362)
Receptive communication (n = 88)	9.375 (2.772)
Expressive communication (n = 89)	10.022 (2.335)
Language composite score (n = 88)	98.523 (10.848)
14-month	
Attachment category (n = 60)	**N (%)**
Secure	34 (56.7)
Insecure	26 (43.3)

TABLE 3 | Covariate analysis between maternal demographic characteristics and independent variable of interest.

	Maternal age r (p-value)	Maternal ethnicity t (p-value)	Maternal income F (p-value)	Maternal education F (p-value)
Prenatal				
Social support satisfaction	0.071 (0.224)	0.917 (0.365)	0.561 (0.691)	0.383 (0.682)
Number of social support persons	−0.029 (0.620)	0.362 (0.719)	0.308 (0.873)	1.395 (0.251)
Neonate				
Social brain network connectivity	0.012 (0.939)	−1.094 (0.308)	0.745 (0.533)	2.326 (0.119)
4-month				
Maternal sensitivity (warmth + responsiveness)	0.054 (0.645)	0.709 (0.490)	1.336 (0.268)	2.070 (0.138)
Infant social skill development	0.157 (0.179)	−0.817 (0.430)	0.688 (0.634)	0.430 (0.653)
Infant language development	0.094 (0.384)	0.429 (0.674)	0.478 (0.792)	1.109 (0.337)

increased social support during pregnancy has been associated with a lower likelihood of depression and anxiety and can buffer its effects (Filippetti et al. 2022; Harrison et al. 2022; Modde Epstein et al. 2024; Tani and Castagna 2017). Mental health factors can impact how mothers and infants interact (Bernard et al. 2018; Graham et al. 2018), and can affect early attachment and infant social-emotional development (Feldman et al. 2009; Filippetti et al. 2022; Norcross et al. 2017). Mothers who experience more satisfaction with their support while pregnant can experience positive buffering effects on their mental health prenatally that also continue postnatally (Modde Epstein et al. 2024; Tani and Castagna 2017), and, thus, mothers may be better able to promote their child's social development through refinement processes with maternal-infant interactions (Hoehl and Bertenthal 2021). In addition to better understanding the continuity of the social support environment postnatally, maternal mental health, both prenatally and postnatally, will be important to consider in future studies to further understand possible interaction effects between

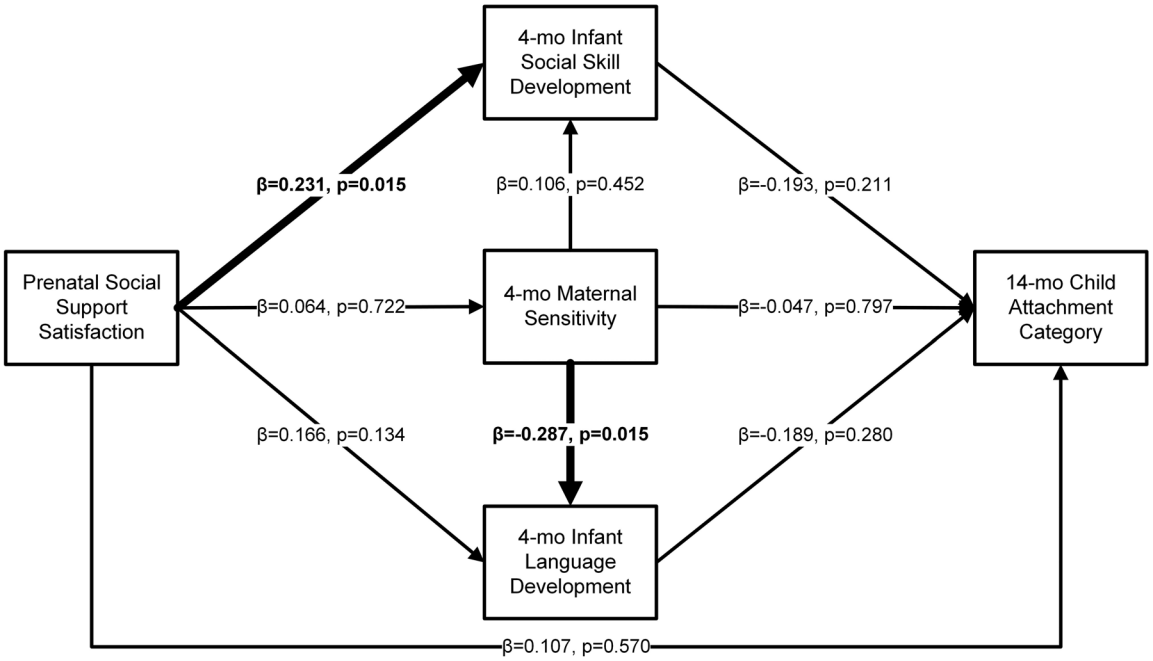


FIGURE 1 | Associations between prenatal social support satisfaction, maternal sensitivity (warmth + responsiveness), child social skill, language, and attachment development.

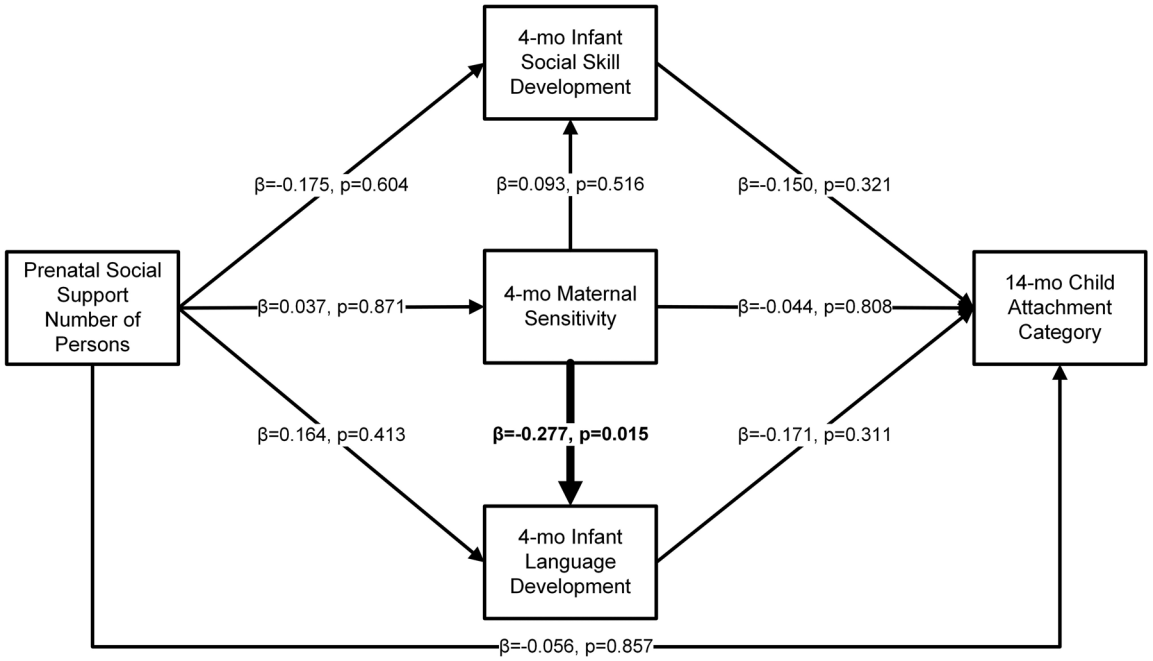


FIGURE 2 | Associations between prenatal social support number of persons, maternal sensitivity (warmth + responsiveness), child social skill, language, and attachment development.

social support and mental health that could influence maternal behavior and infant development.

Additionally, it is important to consider that mothers' self-reported both their perceived satisfaction with social support in pregnancy and their child's social skills at 4 months of age. Mothers' reports may have reflected a positive bias in viewing other people in their life, which is a potential confound and may have affected the positive association found between maternal social support satisfaction and infant social skills. Additionally, this response bias may have affected the null association seen between prenatal social support and maternal sensitivity at 4 months postnatally, which was an observed measure. Future studies should consider using additional observed measures for maternal social support or infant social skill development to better understand this association.

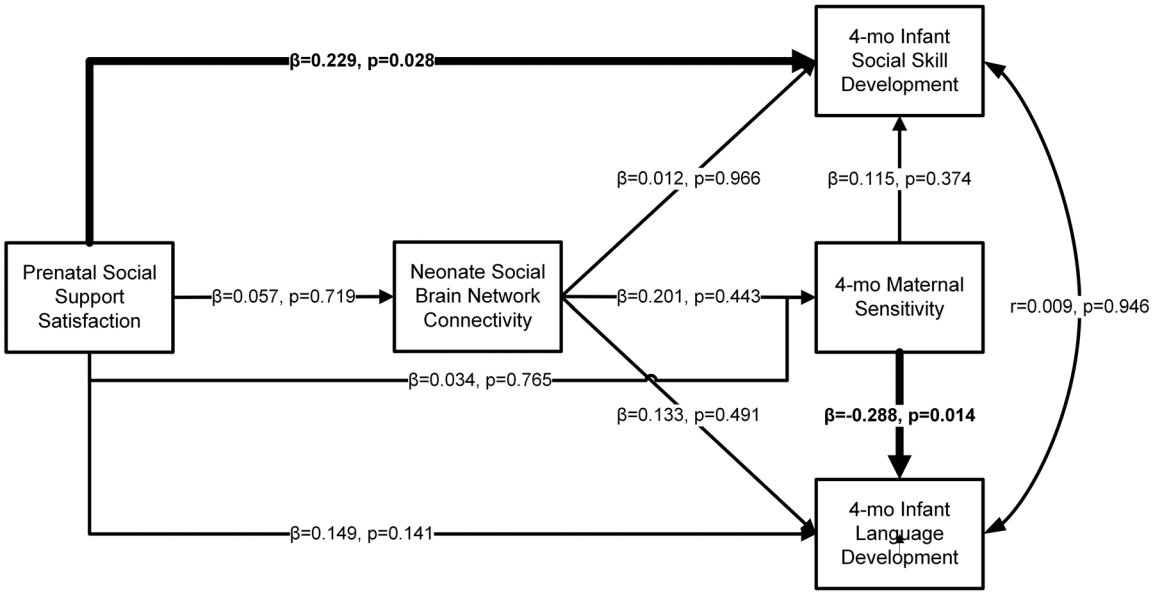


FIGURE 3 | Associations between prenatal social support number of persons, neonate social brain network connectivity, maternal sensitivity (warmth + responsiveness), infant social skill, and language development.

4.2 | Role of Maternal Sensitivity in Language Development

This study adds to literature supporting a link between maternal sensitivity and child language development. Prior research in the literature supports a positive effect of maternal sensitivity on child language development, even as early as 9 months (Borairi et al. 2021; Bornstein et al. 2020; Goldstein and Schwade 2008; Leigh et al. 2011; Madigan et al. 2019). In contrast, this study found that infants who were exposed to higher maternal warmth and responsiveness during play had lower language abilities. Several possibilities could account for this. First, a moderate level of responsiveness has been shown to be more effective for child development rather than higher amounts (Bornstein and Manian 2013). High levels of responsiveness may be intrusive or inappropriate, rather than optimally support the infants' development. Over-responsiveness can limit the development of self-reliance and strain communication (Beebe et al. 2008; Bornstein and Manian 2013; van den Boom 1994). For example, if caregivers are immediately responsive towards their children's cues, children may not have opportunities to utilize or develop further skills to interact with the environment, such as communicating a want or indicating they understand a request. This could account for this relationship in this study. Second, both maternal sensitivity and infant language were measured at 4 months in this study. At this age, it may be developmentally appropriate for parents to provide a higher level of responsiveness to their young infants, and infant communication and language skills may be limited in their assessment. Third, infants in this largely Hispanic/Latino sample may have been exposed to more than one language within the first four months of life or resided in homes where the main language exposure was not English. Bilingual children can score lower on standardized language assessments that only assess one language, but are comparable to monolingual children when considering both language accomplishments (Hoff et al. 2012). Assessments for this study were conducted in English, and thus, lower scores from infants where this was the case may account for a negative association between maternal sensitivity and infant language development. Future studies should incorporate measures of child language at later ages and multiple languages to better understand the effects of maternal sensitivity in early infancy on child language development in diverse populations.

4.3 | Emergence of Social Brain Network in Relation to Prenatal and Postnatal Factors

Prenatal social support does not appear to prime the neonate social brain network, nor does the neonate social brain network impact maternal or infant social behavior at 4 months. While social networks emerge in infancy (Mcpartland and Pelphrey 2012), the young age of the neonates in this study may have limited the relative strength of connections between social areas, as they were limited in exposure to complex postnatal social environments. Rapid neurodevelopment and continued exposure to social environments may continue to contribute to the development of the social brain network. A growing body of literature demonstrates the impact of postnatal maternal sensitivity on offspring neurodevelopment, particularly functional connectivity, in areas related to stress and social-emotional regulation in infancy and into childhood (Copeland et al. 2022; Lee et al. 2019; Rifkin-Graboi et al. 2015). Additionally, early neurodevelopment can play a role in susceptibility to social environmental exposures (Nolvi et al. 2020). Given this, and as disruptions in early specialization of social areas of the brain can have cascading effects for neurodevelopment (Pelphrey et al. 2011), future studies should continue to probe the connectivity of social brain network areas across the full spectrum of infancy as exposure to complex social environments increases. This will provide the opportunity to investigate how variations in early caregiving environments prenatally and postnatally may impact and interact with offspring social-emotional brain development longitudinally.

4.4 | Strengths, Limitations, and Future Directions

This study has several strengths. This study includes the measurement of both maternal and offspring social factors across multiple timepoints from the prenatal period through 24 months of age for the offspring. This allowed more complicated statistical analysis to be used. The use of path analysis can aid in illuminating how these social-emotional factors work together and the complex relationships that may exist between them. The inclusion of two maternal sensitivity measures at the same timepoint was unique and provided the opportunity to explore effects of different dimensions of sensitivity on infant social-emotional development.

This study has several limitations. The sample size of this study was small and varied across social-emotional factors, which may have impacted analysis. This was especially apparent with the small sample size of neonates with social brain network functional connectivity. The age of imaging data used to derive functional connectivity has a coarse resolution compared to current field norms, which may have affected our results in this area. Additionally, the sample was a majority Hispanic/Latino and comprised of adolescents and young adults, so findings may not be generalizable to other populations. Adolescent mothers have been found to be less sensitive and more intrusive during interactions with their children than adult counterparts (Firk et al. 2018; Krpan et al. 2005; Lee 2009), and these differences may have impacted this study. Future studies should include adult populations in pregnancy and larger, more diverse samples, particularly those with more current imaging data, to better understand social-emotional processes between maternal-offspring dyads over time.

5 | Conclusions

This study supports the importance of maternal satisfaction with social support during pregnancy for infant social development. It adds to the evidence that supports a relationship between maternal sensitivity and child language development, and that maternal responsiveness is a critical component of sensitive behavior. Both social support during pregnancy and maternal responsiveness have served as mechanisms for intervention development (Baranek et al. 2015; Landry et al. 2008; Weis and Ryan 2012), and findings from this study support future intervention research with these modifiable targets to facilitate long-term offspring social-emotional development. Future studies should also engage larger and more diverse samples to better understand the intergenerational and bidirectional effects of maternal-offspring social behaviors.

Author Contributions

Cristin M. Holland: conceptualization, formal analysis, funding acquisition, methodology, project administration, software, visualization, writing – original draft, writing – review and editing. **Huili Sun**: data curation, formal analysis, writing – original draft, writing – review and editing. **Raimundo X. Rodriguez**: data curation, formal analysis, visualization, writing – original draft, writing – review and editing. **Margaret Bennett**: data curation, formal analysis, writing – review and editing. **Bin Cheng**: formal analysis, methodology, validation, writing – review and editing. **Bradley S. Peterson**: conceptualization, data curation, funding acquisition, investigation, methodology, resources, writing – review and editing. **Dustin Scheinost**: conceptualization, data curation, formal analysis, funding acquisition, methodology, resources, software, validation, visualization, writing – original draft, writing – review and editing. **Marisa N. Spann**: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, writing – review and editing.

Acknowledgments

We want to thank the participants in this study, our research assistants and staffs, Alida Davis, Ashley Rainford, and Grace Liu for dedicated help with participant engagement, and data collection and/or management. We would also like to thank Drs. Ruth Ottoman and Catherine Monk, Dr. Howard Steele for his support in coding the Strange Situation paradigm, and Drs. Emily Merz and Emily Steinberg for their support in coding maternal sensitivity.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

This work was supported by the Eunice Kennedy Shriver National Institute for Child Health and Human Development K23HD092589 (MS); National Institute of Mental Health [grant numbers R01MH093677 (BSP), K24MH127381 (MS), and R01MH126133 (MS & DS)]; and the National Center for Advancing Translational Sciences [grant number TL1TR001875 (CMH)].

Ethics Statement

Study procedures were approved by the Institutional Review Board of the New York State Psychiatric Institute/Columbia University Medical Center, and all participants provided written informed consent.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study. Data are not available as the consent form at the time of the study did not have the provision for this.

Peer Review

The peer review history for this article is available at https://doi.org/10.1002/brb3.71059.

References

Baranek, G. T., L. R. Watson, L. Turner-Brown, et al. 2015. "Preliminary Efficacy of Adapted Responsive Teaching for Infants at Risk of Autism Spectrum Disorder in a Community Sample." *Autism Research and Treatment* 2015: 386951. https://doi.org/10.1155/2015/386951.

Barton, J. J. S. 2022. "Chapter 11—Face Processing in the Temporal Lobe." In *Handbook of Clinical Neurology*, edited by G. Miceli, P. Bartolomeo, and V. Navarro, 191–210. Elsevier. https://doi.org/10.1016/B978-0-12-823493-8.00019-5.

Bayley, N. 2006. *Bayley scales of infant and toddler development*. (3rd ed.) [Measurement instrument] San Antonio, TX: Pearson.

Beebe, B., J. Jaffe, K. Buck, et al. 2008. "Six-Week Postpartum Maternal Depressive Symptoms and 4-Month Mother–Infant Self- and Interactive Contingency." *Infant Mental Health Journal* 29, no. 5: 442–471. https://doi.org/10.1002/imhj.20191.

Bernard, K., G. Nissim, S. Vaccaro, J. L. Harris, and O. Lindhiem. 2018. "Association Between Maternal Depression and Maternal Sensitivity From Birth to 12 Months: A Meta-Analysis." *Attachment & Human Development* 20, no. 6: 578–599. https://doi.org/10.1080/14616734.2018.1430839.

Bigelow, A. E., K. MacLean, J. Proctor, T. Myatt, R. Gillis, and M. Power. 2010. "Maternal Sensitivity Throughout Infancy: Continuity and Relation to Attachment Security." *Infant Behavior and Development* 33, no. 1: 50–60. https://doi.org/10.1016/j.infbeh.2009.10.009.

Borairi, S., P. Fearon, S. Madigan, A. Plamondon, and J. Jenkins. 2021. "A Mediation Meta-Analysis of the Role of Maternal Responsivity in the Association Between Socioeconomic Risk and Children's Language." *Child Development* 92, no. 6: 2177–2193. https://doi.org/10.1111/cdev.13695.

Bornstein, M. H., and N. Manian. 2013. "Maternal Responsiveness and Sensitivity Reconsidered: Some Is More." *Development and Psychopathology* 25, no. 4: 957–971. https://doi.org/10.1017/S0954579413000308.

Bornstein, M. H., D. L. Putnick, Y. Bohr, M. Abdelmaseh, C. Y. Lee, and G. Esposito. 2020. "Maternal Sensitivity and Language in Infancy Each Promotes Child Core Language Skill in Preschool." *Early Childhood Research Quarterly* 51: 483–489. https://doi.org/10.1016/j.ecresq.2020.01.002.

Boyce, W. T., P. Levitt, F. D. Martinez, B. S. McEwen, and J. P. Shonkoff. 2021. "Genes, Environments, and Time: the Biology of Adversity and Resilience." *Pediatrics* 147, no. 2: e20201651. https://doi.org/10.1542/peds.2020-1651.

Braungart-Rieker, J. M., S. Zentall, D. M. Lickenbrock, N. V. Ekas, T. Oshio, and E. Planalp. 2014. "Attachment in the Making: Mother and Father Sensitivity and Infants' Responses During the Still-Face Paradigm." *Journal of Experimental Child Psychology* 125: 63–84. https://doi.org/10.1016/j.jecp.2014.02.007.

Brewer, J., K. Garrison, and S. Whitfield-Gabrieli. 2013. "What About the "Self" Is Processed in the Posterior Cingulate Cortex?" *Frontiers in Human Neuroscience* 7: 647. https://doi.org/10.3389/fnhum.2013.00647.

Cooke, J. E., L. B. Kochendorfer, K. L. Stuart-Parrigon, A. J. Koehn, and K. A. Kerns. 2019. "Parent–Child Attachment and Children's Experience and Regulation of Emotion: A Meta-Analytic Review." *Emotion* 19, no. 6: 1103–1126. https://doi.org/10.1037/emo0000504.

Copeland, A., R. Korja, S. Nolvi, et al. 2022. "Maternal Sensitivity at the Age of 8 Months Associates With Local Connectivity of the Medial Prefrontal Cortex in Children at 5 Years of Age." *Frontiers in Neuroscience* 16: 920995. https://doi.org/10.3389/fnins.2022.920995.

Curley, J. P., and F. A. Champagne. 2016. "Influence of Maternal Care on the Developing Brain: Mechanisms, Temporal Dynamics and Sensitive Periods." *Frontiers in Neuroendocrinology* 40: 52–66. https://doi.org/10.1016/j.yfrne.2015.11.001.

Feldman, R., A. Granat, C. Pariente, H. Kanety, J. Kuint, and E. Gilboa-Schechtman. 2009. "Maternal Depression and Anxiety Across the Postpartum Year and Infant Social Engagement, Fear Regulation, and Stress Reactivity." *Journal of the American Academy of Child & Adolescent Psychiatry* 48, no. 9: 919–927. https://doi.org/10.1097/CHI.0b013e3181b21651.

Filippetti, M. L., A. D. F. Clarke, and S. Rigato. 2022. "The Mental Health Crisis of Expectant Women in the UK: Effects of the COVID-19 Pandemic on Prenatal Mental Health, Antenatal Attachment and Social Support." *BMC Pregnancy and Childbirth* 22: 1–10. https://doi.org/10.1186/s12884-022-04387-7.

Firk, C., K. Konrad, B. Herpertz-Dahlmann, W. Scharke, and B. Dahmen. 2018. "Cognitive Development in Children of Adolescent Mothers: the Impact of Socioeconomic Risk and Maternal Sensitivity." *Infant Behavior and Development* 50: 238–246. https://doi.org/10.1016/j.infbeh.2018.02.002.

Frigerio, A., and S. Nazzari. 2021. "Antenatal Maternal Anxiety, Maternal Sensitivity and Toddlers' Behavioral Problems: An Investigation of Possible Pathways." *Early Human Development* 157: 105364. https://doi.org/10.1016/j.earlhumdev.2021.105364.

Gagné, K., J.-P. Lemelin, and G. M. Tarabulsy. 2021. "Non-Verbal and Verbal Parental Mentalization as Predictors of Infant Attachment Security: Contributions of Parental Embodied Mentalizing and Mind-Mindedness and the Mediating Role of Maternal Sensitivity." *Infant Behavior and Development* 65: 101622. https://doi.org/10.1016/j.infbeh.2021.101622.

Gangopadhyay, P., M. Chawla, O. Dal Monte, and S. W. C. Chang. 2021. "Prefrontal–Amygdala Circuits in Social Decision-Making." *Nature Neuroscience* 24, no. 1: 5–18. https://doi.org/10.1038/s41593-020-00738-9.

Goldstein, M. H., and J. A. Schwade. 2008. "Social Feedback to Infants' Babbling Facilitates Rapid Phonological Learning." *Psychological Science* 19, no. 5: 515–523.

Gordon, I., A. C. Voos, R. H. Bennett, D. Z. Bolling, K. A. Pelphrey, and M. D. Kaiser. 2011. "Brain Mechanisms for Processing Affective Touch." *Human Brain Mapping* 34, no. 4: 914–922. https://doi.org/10.1002/hbm.21480.

Graham, K. A., J. Blissett, E. E. Antoniou, M. P. Zeegers, and J. P. McCleery. 2018. "Effects of Maternal Depression in the Still-Face Paradigm: A Meta-Analysis." *Infant Behavior and Development* 50: 154–164. https://doi.org/10.1016/j.infbeh.2017.12.001.

Grant, K.-A., C. McMahon, N. Reilly, and M.-P. Austin. 2010. "Maternal Sensitivity Moderates the Impact of Prenatal Anxiety Disorder on Infant Mental Development." *Early Human Development* 86, no. 9: 551–556. https://doi.org/10.1016/j.earlhumdev.2010.07.004.

Grossmann, T., and M. H. Johnson. 2007. "The Development of the Social Brain in Human Infancy." *European Journal of Neuroscience* 25, no. 4: 909–919. https://doi.org/10.1111/j.1460-9568.2007.05379.x.

Hallgren, K. A. 2012. "Computing Inter-Rater Reliability for Observational Data: An Overview and Tutorial." *Tutorials in Quantitative Methods for Psychology* 8, no. 1: 23–34.

Harrison, V., M. L. Moulds, and K. Jones. 2022. "Perceived Social Support and Prenatal Wellbeing; The Mediating Effects of Loneliness and Repetitive Negative Thinking on Anxiety and Depression During the COVID-19 Pandemic." *Women and Birth* 35, no. 3: 232–241. https://doi.org/10.1016/j.wombi.2020.12.014.

Hoehl, S., and B. I. Bertenthal. 2021. "Chapter One—An Interactionist Perspective on the Development of Coordinated Social attention." In *Advances in Child Development and Behavior*, edited by J. J. Lockman, 1–41. JAI. https://doi.org/10.1016/bs.acdb.2021.05.001.

Hoff, E., C. Core, S. Place, R. Rumiche, M. Señor, and M. Parra. 2012. "Dual Language Exposure and Early Bilingual Development." *Journal of Child Language* 39, no. 1: 1–27. https://doi.org/10.1017/S0305000910000759.

Huang, W.-C., A. Zucca, J. Levy, and D. T. Page. 2020. "Social Behavior Is Modulated by Valence-Encoding mPFC-Amygdala Sub-Circuitry." *Cell Reports* 32, no. 2: 107899. https://doi.org/10.1016/j.celrep.2020.107899.

Ilyka, D., M. H. Johnson, and S. Lloyd-Fox. 2021. "Infant Social Interactions and Brain Development: A Systematic Review." *Neuroscience & Biobehavioral Reviews* 130: 448–469. https://doi.org/10.1016/j.neubiorev.2021.09.001.

Jacobson, S. W., and K. F. Frye. 1991. "Effect of Maternal Social Support on Attachment: Experimental Evidence." *Child Development* 62, no. 3: 572–582. https://doi.org/10.2307/1131132.

Joshi, A., D. Scheinost, H. Okuda, et al. 2011. "Unified Framework for Development, Deployment and Robust Testing of Neuroimaging Algorithms." *Neuroinformatics* 9, no. 1: 69–84. https://doi.org/10.1007/s12021-010-9092-8.

Krpan, K. M., R. Coombs, D. Zinga, M. Steiner, and A. S. Fleming. 2005. "Experiential and Hormonal Correlates of Maternal Behavior in Teen and Adult Mothers." *Hormones and Behavior* 47, no. 1: 112–122. https://doi.org/10.1016/j.yhbeh.2004.08.006.

Landry, S. H., K. E. Smith, C. L. Miller-Loncar, and P. R. Swank. 1997. "Predicting Cognitive-Language and Social Growth Curves From Early

Maternal Behaviors in Children at Varying Degrees of Biological Risk." *Developmental Psychology* 33, no. 6: 1040–1053. https://doi.org.libproxy1.usc.edu/10.1037/0012-1649.33.6.1040.

Landry, S. H., K. E. Smith, and P. R. Swank. 2006. "Responsive Parenting: Establishing Early Foundations for Social, Communication, and Independent Problem-Solving Skills." *Developmental Psychology* 42, no. 4: 627–642. https://doi.org.libproxy1.usc.edu/10.1037/0012-1649.42.4.627.

Landry, S. H., K. E. Smith, P. R. Swank, M. A. Assel, and S. Vellet. 2001. "Does Early Responsive Parenting Have a Special Importance for Children's Development or Is Consistency Across Early Childhood Necessary?" *Developmental Psychology* 37, no. 3: 387–403. https://doi.org.libproxy2.usc.edu/10.1037/0012-1649.37.3.387.

Landry, S. H., K. E. Smith, P. R. Swank, and C. Guttentag. 2008. "A Responsive Parenting Intervention: The Optimal Timing Across Early Childhood for Impacting Maternal Behaviors and Child Outcomes." *Developmental Psychology* 44, no. 5: 1335–1353. https://doi.org.libproxy2.usc.edu/10.1037/a0013030.

Lee, A., J. S. Poh, D. J. Wen, et al. 2019. "Maternal Care in Infancy and the Course of Limbic Development." *Developmental Cognitive Neuroscience* 40: 100714. https://doi.org/10.1016/j.dcn.2019.100714.

Lee, Y. 2009. "Early Motherhood and Harsh Parenting: The Role of Human, Social, and Cultural Capital." *Child Abuse & Neglect* 33, no. 9: 625–637. https://doi.org/10.1016/j.chiabu.2009.02.007.

Leech, R., S. Kamourieh, C. F. Beckmann, and D. J. Sharp. 2011. "Fractionating the Default Mode Network: Distinct Contributions of the Ventral and Dorsal Posterior Cingulate Cortex to Cognitive Control." *The Journal of Neuroscience* 31, no. 9: 3217–3224. https://doi.org/10.1523/JNEUROSCI.5626-10.2011.

Leigh, P., M. A. Nievar, and L. Nathans. 2011. "Maternal Sensitivity and Language in Early Childhood: A Test of the Transactional Model." *Perceptual and Motor Skills* 113, no. 1: 281–299. https://doi.org/10.2466/10.17.21.28.PMS.113.4.281-299.

Leung, M.-K., and W. K.-W. Lau. 2020. "Chapter Five—Resting-State Abnormalities of Posterior Cingulate in Autism Spectrum Disorder." In *Progress in Molecular Biology and Translational Science*, edited by M. Ilieva and W. K.-W. Lau, 139–159. Academic Press. https://doi.org/10.1016/bs.pmbts.2020.04.010.

Madigan, S., H. Prime, S. A. Graham, et al. 2019. "Parenting Behavior and Child Language: A Meta-Analysis." *Pediatrics* 144, no. 4: e20183556. https://doi.org/10.1542/peds.2018-3556.

Mcpartland, J. C., and K. A. Pelphrey. 2012. "The Implications of Social Neuroscience for Social Disability." *Journal of Autism and Developmental Disorders* 42, no. 6: 1256–1262. https://doi.org/10.1007/s10803-012-1514-z.

Merz, E. C., T. A. Zucker, S. H. Landry, et al. 2015. "Parenting Predictors of Cognitive Skills and Emotion Knowledge in Socioeconomically Disadvantaged Preschoolers." *Journal of Experimental Child Psychology* 132: 14–31. https://doi.org/10.1016/j.jecp.2014.11.010.

Modde Epstein, C., M. J. Rice, J. A. French, K. A. Kupzyk, and J. F. Houfek. 2024. "Social Support Buffers the Effects of Prenatal Depressed Mood: A Mixed-Methods Study." *Journal of the American Psychiatric Nurses Association* 30, no. 1: 95–107. https://doi.org/10.1177/10783903211073793.

Noble, S., M. N. Spann, F. Tokoglu, X. Shen, R. T. Constable, and D. Scheinost. 2017. "Influences on the Test–Retest Reliability of Functional Connectivity MRI and Its Relationship With Behavioral Utility." *Cerebral Cortex* 27, no. 11: 5415–5429. https://doi.org/10.1093/cercor/bhx230.

Nolvi, S., J. M. Rasmussen, A. M. Graham, et al. 2020. "Neonatal Brain Volume as a Marker of Differential Susceptibility to Parenting Quality and Its Association With Neurodevelopment Across Early Childhood." *Developmental Cognitive Neuroscience* 45: 100826. https://doi.org/10.1016/j.dcn.2020.100826.

Norcross, P. L., E. M. Leerkes, and N. Zhou. 2017. "Examining Pathways Linking Maternal Depressive Symptoms in Infancy to Children's Behavior Problems: The Role of Maternal Unresponsiveness and Negative Behaviors." *Infant Behavior & Development* 49: 238–247. https://doi.org/10.1016/j.infbeh.2017.09.009.

Pearson, R. M., J. Heron, R. Melotti, et al. 2011. "The Association Between Observed Non-Verbal Maternal Responses at 12 Months and Later Infant Development at 18 Months and IQ at 4 Years: A Longitudinal Study." *Infant Behavior and Development* 34, no. 4: 525–533. https://doi.org/10.1016/j.infbeh.2011.07.003.

Peled-Avron, L., L. Glasner, H. Z. Gvirts, and S. G. Shamay-Tsoory. 2019. "The Role of the Inferior Frontal Gyrus in Vicarious Social Touch: A Transcranial Direct Current Stimulation (tDCS) Study." *Developmental Cognitive Neuroscience* 35: 115–121. https://doi.org/10.1016/j.dcn.2018.04.010.

Pelphrey, K. A., and E. J. Carter. 2008. "Brain Mechanisms for Social Perception." *Annals of the New York Academy of Sciences* 1145, no. 1: 283–299. https://doi.org/10.1196/annals.1416.007.

Pelphrey, K. A., S. Shultz, C. M. Hudac, and B. C. V. Wyk. 2011. "Constraining Heterogeneity: The Social Brain and Its Development in Autism Spectrum Disorder." *Journal of Child Psychology and Psychiatry, and Allied Disciplines* 52, no. 6: 631–644. https://doi.org/10.1111/j.1469-7610.2010.02349.x.

Ponti, L., M. Smorti, S. Ghinassi, and F. Tani. 2021. "The Relationship Between Romantic and Prenatal Maternal Attachment: The Moderating Role of Social Support." *International Journal of Psychology* 56, no. 1: 143–150. https://doi.org/10.1002/ijop.12676.

Poulin-Dubois, D. 2020. "Chapter 7 - Theory of Mind Development: State of the Science and Future Directions." In *Progress in Brain Research*, edited by S. Hunnius, and M. Meyer, 141–166. Elsevier. https://doi.org/10.1016/bs.pbr.2020.05.021.

Rifkin-Graboi, A., L. Kong, L. W. Sim, et al. 2015. "Maternal Sensitivity, Infant Limbic Structure Volume and Functional Connectivity: A Preliminary Study." *Translational Psychiatry* 5, no. 10: e668–e668. https://doi.org/10.1038/tp.2015.133.

Scheinost, D., S. H. Kwon, C. Lacadie, et al. 2017. "Alterations in Anatomical Covariance in the Prematurely Born." *Cerebral Cortex* 27, no. 1: 534–543. https://doi.org/10.1093/cercor/bhv248.

Scheinost, D., S. H. Kwon, X. Shen, et al. 2016. "Preterm Birth Alters Neonatal, Functional Rich Club Organization." *Brain Structure and Function* 221, no. 6: 3211–3222. https://doi.org/10.1007/s00429-015-1096-6.

Smith, E., Y. Xiao, H. Xie, et al. 2023. "Posterior Superior Temporal Cortex Connectivity Is Related to Social Communication in Toddlers." *Infant Behavior and Development* 71: 101831. https://doi.org/10.1016/j.infbeh.2023.101831.

Spann, M. N., R. Bansal, X. Hao, T. S. Rosen, and B. S. Peterson. 2020. "Prenatal Socioeconomic Status and Social Support Are Associated With Neonatal Brain Morphology, Toddler Language and Psychiatric Symptoms." *Child Neuropsychology : A Journal on Normal and Abnormal Development in Childhood and Adolescence* 26, no. 2: 170–188. https://doi.org/10.1080/09297049.2019.1648641.

Sroufe, L. A. 2005. "Attachment and Development: A Prospective, Longitudinal Study From Birth to Adulthood." *Attachment & Human Development* 7, no. 4: 349–367. https://doi.org/10.1080/14616730500365928.

Sroufe, L. A., B. Egeland, E. A. Carlson, and W. A. Collins. 2005. *The Development of the Person: The Minnesota Study of Risk and Adaptation From Birth to Adulthood*. Guilford Publications.

Takács, L., J. Štipl, M. Gartstein, S. P. Putnam, and C. Monk. 2021. "Social Support Buffers the Effects of Maternal Prenatal Stress on Infants' Unpredictability." *Early Human Development* 157: 105352. https://doi.org/10.1016/j.earlhumdev.2021.105352.

Tani, F., and V. Castagna. 2017. "Maternal Social Support, Quality of Birth Experience, and Post-Partum Depression in Primiparous Women." *The Journal of Maternal-Fetal & Neonatal Medicine* 30, no. 6: 689–692. https://doi.org/10.1080/14767058.2016.1182980.

Thomas, J. C., N. Letourneau, T. S. Campbell, L. Tomfohr-Madsen, and G. F. Giesbrecht. 2017. "Developmental Origins of Infant Emotion Regulation: Mediation by Temperamental Negativity and Moderation by Maternal Sensitivity." *Developmental Psychology* 53, no. 4: 611–628. https://doi.org.libproxy1.usc.edu/10.1037/dev0000279.

van den Boom, D. C. 1994. "The Influence of Temperament and Mothering on Attachment and Exploration: an Experimental Manipulation of Sensitive Responsiveness Among Lower-Class Mothers With Irritable Infants." *Child Development* 65, no. 5: 1457–1477. https://doi.org/10.1111/j.1467-8624.1994.tb00829.x.

Van Dijk, K. R. A., M. R. Sabuncu, and R. L. Buckner. 2012. "The Influence of Head Motion on Intrinsic Functional Connectivity MRI." *Neuroimage* 59, no. 1: 431–438. https://doi.org/10.1016/j.neuroimage.2011.07.044.

Weis, K. L., and T. W. Ryan. 2012. "Mentors Offering Maternal Support: A Support Intervention for Military Mothers." *Journal of Obstetric, Gynecologic & Neonatal Nursing* 41, no. 2: 303–314. https://doi.org/10.1111/j.1552-6909.2012.01346.x.

Wurster, H. E., M. Sarche, C. Trucksess, B. Morse, and Z. Biringen. 2020. "Parents' Adverse Childhood Experiences and Parent–Child Emotional Availability in an American Indian Community: Relations With Young Children's Social–Emotional Development." *Development and Psychopathology* 32, no. 2: 425–436. https://doi.org/10.1017/S095457941900018X.

Yang, D. Y.-J., G. Rosenblau, C. Keifer, and K. A. Pelphrey. 2015. "An Integrative Neural Model of Social Perception, Action Observation, and Theory of Mind." *Neuroscience & Biobehavioral Reviews* 51: 263–275. https://doi.org/10.1016/j.neubiorev.2015.01.020.

Ziv, Y., O. Aviezer, M. Gini, A. Sagi, and N. K. Karie. 2000. "Emotional Availability in the Mother–Infant Dyad as Related to the Quality of Infant–Mother Attachment Relationship." *Attachment & Human Development* 2, no. 2: 149–169. https://doi.org/10.1080/14616730050085536.

Ziv, Y., K. L. C. Umphlet, S. Olarte, and J. Venza. 2018. "Early Childhood Trauma in High-Risk Families: Associations With Caregiver Emotional Availability and Insightfulness, and Children's Social Information Processing and Social Behavior." *Attachment & Human Development* 20, no. 3: 309–332. https://doi.org/10.1080/14616734.2018.1446738.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supplementary Figure: brb371059-sup-0001-FigureS1.jpeg