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Temperamental Susceptibility to Parenting among Preterm and Full-Term Infants in Early Cognitive Development

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The current study examined the interaction between premature birth, temperamental reactivity, and parenting in early cognitive development. Participants were 142 infants (80 preterm; 62 full term) and their parents. Parent–child interactions (maternal, paternal, and co-parental) were observed at age 6 months to assess parental structuring behaviors. Additionally, both parents reported on infants' temperamental reactivity. At 12 months of age, infants' cognitive abilities were assessed. Consistent with the diathesis–stress model, preterm infants had lower cognitive outcomes than full-term infants when exposed to low levels of co-parental structuring, but functioned similarly when exposed to high levels of co-parental structuring. However, temperamental reactivity moderated this effect: Infants who carried one susceptibility factor (i.e., premature birth or reactive temperament) were similarly affected by co-parental structuring, whereas infants who carried two or no susceptibility factors were not. Furthermore, consistent with the differential susceptibility hypothesis, infants with highly reactive temperaments had lower cognitive functioning when exposed to low maternal structuring, but higher cognitive functioning when exposed to high maternal structuring compared to infants with lower reactivity. Results from this study highlight the importance of considering both temperamental reactivity and quality of parenting in understanding preterm infants' early cognitive vulnerability.

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Premature birth is considered to be a biological vulnerability factor that confers increased risk for poor cognitive outcomes (Aylward, 2005). Substantial evidence suggests that even under low medical risk conditions, infants born preterm score lower than full-term infants on standard cognitive assessments (Brummelte, Grunau, Synnes, Whitfield, & Petrie-Thomas, 2011; Lowe, Erickson, MacLean, Schrader, & Fuller, 2013). This cognitive vulnerability is evident among both very preterm (<32 weeks gestation or <1,500 g birth weight) and moderately to late preterm (≥32 weeks gestation and ≥1,500 birth weight) infants (Voigt, Pietz, Pauen, Kliegel, & Reuner, 2012). Throughout childhood, children born preterm continue to show a broad range of cognitive difficulties including lower IQ, poorer school achievement, and a relatively high incidence of learning disabilities compared to children born at full term (e.g., Aylward, 2005; Bhutta, Cleves, Casey, Cradock, & Anand, 2002). However, the risk associated with premature birth is not homogeneous, and environmental factors such as parenting style, parental mental health, and the home environment have been found to contribute to the variance in cognitive outcomes found in children born preterm (Gueron-Sela, Atzaba-Poria, Meiri, & Marks, 2015; McManus & Poehlmann, 2012). Relying on theoretical frameworks suggesting that some children are more strongly affected by their caregiving environments than others (Ellis, Boyce, Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2011), it has recently been suggested that infants born prematurely or at low birthweights may be more susceptible to the effects of the caregiving environment on development than their full-term counterparts (Gueron-Sela et al., 2015; Jaekel, Pluess, Belsky, & Wolke, 2014). Temperamental reactivity (i.e., proneness to distress) is a well-established susceptibility factor to parenting (Belsky, Bakermans-Kranenburg, & van Ijzendoorn, 2007), which may contribute to the variability in preterm infants' cognitive outcomes (Poehlmann et al., 2012). In an attempt to further understand preterm infants' susceptibility to caregiving, this study investigated the interaction between premature birth, temperamental reactivity, and parenting in early cognitive development. To that aim, we considered two frameworks for understanding person × environment interactions: diathesis–stress (Monroe & Simons, 1991) and differential susceptibility (Belsky, 2005; Ellis et al., 2011). We also employed a comprehensive assessment of parenting and considered the contribution of three main relationship contexts (i.e., maternal, paternal, and co-parental) to early cognitive development.

Maternal, paternal, and co-parental parenting in preterm infants' development

Research has consistently demonstrated that early sensitive, responsive caregiving environments facilitate preterm infants' later cognitive development (e.g., Landry, Smith, Swank, Assel, & Vellet, 2001; Lowe et al., 2013; Poehlmann & Fiese, 2001). For example, reciprocal and engaging mother–child interactions at age 6 months significantly predicted higher cognitive scores at 12 months of age, controlling for neonatal medical risk (Poehlmann & Fiese, 2001). Furthermore, preterm infants showed faster cognitive growth when their mothers were consistently responsive during the first four years of life (Landry et al., 2001). Specific maternal behaviors, such as maternal scaffolding (i.e., providing appropriate verbal guidance or strategies to help the child solve a problem), have also been positively associated with preterm infants' cognitive outcomes (Lowe et al., 2013). However, while evidence has been accumulating regarding the possible benefits of maternal behaviors among preterm families, the roles of additional relationship contexts have been relatively neglected. One study reported that both mothers' and fathers' positive interactions with their prematurely born infants predicted higher receptive communication skills (Magill-Evans, Harrison, 1999). In addition, high paternal engagement in child care and play predicted higher IQ scores at 3 years of age among children born prematurely (Yogman, Kindlon, & Earls, 1995). These findings highlight the importance of further examining the possible benefits of positive father–child relationships to preterm infants' cognitive development.

A growing body of research suggests that co-parenting dynamics (i.e., the relationship occurring between two adults as they work together to rear a child) contribute to children's developmental outcomes, over and above the contribution of dyadic mother–child and father–child relationships (e.g., Karreman, van Tuijl, van Aken, & Deković, 2008; McHale, Kuersten, & Lauretti, 1996). In the context of cognitive and academic outcomes, higher levels of co-parental conflict and hostility have been associated with poorer literacy and mathematical skills (Cabrera, Scott, Fagan, Steward-Streng, & Chien, 2012) and lower effortful control abilities (Karreman et al., 2008). However, to the best of our knowledge, the possible contributions of co-parenting dynamics to preterm infants' early cognitive development have not yet been examined. Based on a family systems framework, highlighting the interdependent nature of various family relationships and their influences on individual outcomes over time (Cox & Paley, 1997; Minuchin, 1985), this study examined the contributions of parent–child and co-parental relationships to early cognitive development. We also tested whether these contributions differ as a function of premature birth and temperamental reactivity.

Susceptibility to parenting among preterm infants

A substantive body of work has established that behaviorally or biologically reactive children are particularly vulnerable to environmental risk, showing less adaptive outcomes than their peers in the context of negative environmental experiences (e.g., Cummings, El-Sheikh, Kouros, & Keller, 2007; Ramos, Guerin, Gottfried, Bathurst, & Oliver, 2005). Theoretical frameworks based on these findings have been labeled diathesis–stress or dual risk (Monroe & Simons, 1991). However, this traditional view on person $\times$ environment interactions has recently been revisited. Belsky and colleagues (Belsky et al., 2007; Ellis et al., 2011) suggested that children with heightened biological sensitivity (i.e., heightened physiological stress reactivity) or who are temperamentally reactive (i.e., easily frustrated or prone to distress) may be more vulnerable to negative contextual factors, but may also have greater capacity to benefit from positive environments than children who do not carry these biological or temperamental susceptibilities (Ellis et al., 2011). For example, infants prone to negative emotionality had lower self-regulation abilities when they were in unresponsive parent–child relationships, but higher regulatory capacities when in responsive relationships, compared to infants not prone to negative emotionality (Kim & Kochanska, 2012). In a similar manner, it was found that infants who were anger prone showed less prosocial behavior when their mothers were unresponsive, but more prosocial behavior if their mothers were highly responsive, than infants who were not anger prone (Spinrad & Stifter, 2006). There are reasons to suspect that premature birth may act as a susceptibility factor to parenting in early development. Infants born prematurely exhibit un-adaptive physiological regulation capacities, including low vagal tone (Feldman & Eidelman, 2007) and irregular basal cortisol levels (Grunau et al., 2007). Furthermore, premature birth is often associated with abnormalities in brain white matter such as changes in synaptic efficacy, loss of volume, enlarged ventricles, and alterations in the degree of myelination (Inder, Warfield, Wang, Hüppi, & Volpe, 2005) that may result in difficulties in biological and behavioral regulation (Brown, Doyle, Bear, & Inder, 2006; Woodward, Clark, Pritchard, Anderson, & Inder, 2011). These low physiological and behavioral regulation capacities may result in higher dependence on external regulation for "worse" in the case of negative parental behavior, or for "better" in the case of positive parenting practices.

Findings from two recent studies that tested prematurity or low birthweight (LBW) as potential susceptibility factors revealed person × environment interactions that were consistent with a diathesis–stress approach. Specifically, one study found that children born at LBW were more susceptible than normal birthweight children to the adverse effects of low maternal sensitivity, but not beneficial effects of high maternal sensitivity on their academic achievements at age of 8 years (Jaekel et al., 2015). In a similar manner, we recently found that preterm infants had lower cognitive outcomes than full-term infants when exposed to high levels of maternal emotional distress, but did not differ from their counterparts when exposed to low levels of maternal emotional distress (Gueron-Sela et al., 2015). This study focuses on *parental structuring behaviors* which may be particularly supportive of children's cognitive development. Parental structuring behaviors include providing a supportive framework that is appropriate to the child's developmental stage, enabling the child to move to a higher level of competence (Biringen, 2008). Therefore, it may be the case that preterm infants will particularly benefit from high-structuring parental relationships in their cognitive development, and even outperform their full-term counterparts, consistent with the differential susceptibility model.

Temperamental susceptibility among preterm infants

Research investigating preterm infants' early temperamental profiles has yielded inconsistent findings. On one hand, some studies have characterized preterm infants as temperamentally reactive or difficult, and found them to be less adaptable (Gennaro, 1990; Langkamp, Kim, & Pascoe, 1998), higher on negative moods (Langkamp et al., 1998), and more intense (Langkamp & Pascoe, 2001). On the other hand, other studies reported decreased temperamental reactivity including being less active, less intense (Sajaniemi, Salokorpi, & Von Wendt, 1998), and less approaching (Coll, Halpern, Vohr, Seifer, & Oh, 1992) or found no differences in temperamental profiles (Kerestes, 2005) compared to full-term infants. These inconsistent findings suggest that preterm infants may significantly vary in their temperamental reactivity. As temperamental reactivity is a well-established susceptibility factor to parenting (Belsky et al., 2007), it is important to include it when examining prematurity as a susceptibility factor. For example, children with difficult temperaments were more at risk for externalizing behavior problems when exposed to family conflict than children with less difficult temperaments (Whiteside-Mansell, Bradley, Casey, Fussell, & Conners-Burrow, 2009). Similarly, preterm infants who were temperamentally prone to distress were more strongly affected by early maternal behavior in their cognitive development than infants who were not prone to distress (Poehlmann et al., 2012). However, the absence of a full-term comparison group prevented the examination of possible differential temperamental susceptibility between preterm and full-term infants, and how it may affect differences in cognitive outcomes between the groups.

The current study

The current study aimed to expand the ongoing investigation of susceptibility to parenting among preterm infants in two main ways. First, we examined the interactions between two documented susceptibility factors (i.e., prematurity and temperament) and parental structuring in predicting early cognitive development. We distinguished between differential susceptibility (Belsky, 2005; Ellis et al., 2011) and diathesis–stress (Monroe & Simons, 1991) effects by applying recent analytic recommendations that involve the analysis of regions of significance and proportion of the interaction (Roisman et al., 2012). The use of these methods enables a systematic examination of whether cognitive functioning differs as a function of children's susceptibility factors at both high and low levels of the predicting parental structuring variable. Second, moving beyond the traditional focus on maternal behavior, we employed a more comprehensive approach and considered the contribution of three main relationship contexts (maternal, paternal, co-parental), to early cognitive development. The following hypotheses were suggested: (1) Birth status (preterm/full term) would moderate the link between parental structuring at age 6 months and infants' cognitive functioning at age 12 months. Specifically, preterm infants' cognitive functioning would be more strongly affected by parental structuring than full-term infants and that this pattern will be consistent with the differential susceptibility model. (2) Temperamental reactivity would moderate the interaction between birth status and parental structuring in the prediction of cognitive functioning. However, this anticipated statistical interaction could reflect one of two different processes. Infants who carry two susceptibility factors (i.e., premature birth and reactive temperament) may be the most susceptible to parenting in their early cognitive functioning. Alternatively, it may be the case that the combination of these two factors may result in heightened regulatory and behavioral difficulties that may reduce infants' capacity to benefit from optimal environments, or to be negatively affected by less optimal parenting practices. We explored which of these two competing hypotheses best fit the data. Finally, the possible differential associations between the three relationship contexts (maternal, paternal, and co-parental) and the cognitive outcome will be examined. Given the paucity of previous research on this topic, this research goal was exploratory in nature.

METHOD

Participants

Participants were full-term and preterm infants and their parents who were enrolled in the Preterm Early Development Study (PEDS), a prospective, longitudinal study of preterm infants' early cognitive and social development. Infants and their families were recruited shortly after birth and followed up at ages 6 and 12 months (at both time points, age was corrected for prematurity for the preterm group). The inclusion criteria were (1) singleton birth and (2) Jewish Hebrew speaking parents. Furthermore, as the goal of this study was to observe parent–child relationships in the triadic family context, only two-parent families were approached. Due to the low rates of births outside marriage in Israel [5.8% compared to the 36% average in other western countries (Central Bureau of Statistics (2011); The Organization for Economic Co-operation and Development (OECD) Family database (2014)], the vast majority of families were eligible to participate in terms of family composition. Families from the preterm group were recruited from the Neonatal Intensive Care Unit (NICU) and families from the full-term group were recruited from the maternity ward in the largest medical center in the southern region of Israel. The preterm group included infants born between 28 and 33 weeks of gestation with low medical risk. Exclusion criteria included significant neonatal neurological complications and birth weight under 1,000 g. The full-term group included healthy infants born after 37 weeks of gestation. A total of 162 families (87 infants born preterm; 75 infants born at full term) agreed to participate in the study after the infants' birth. At age 6 months, 150 families participated in the assessment (92.6% of the original sample). The preterm group included 83 infants (48 boys, 35 girls) (Mage = 5.9 months, $SD = .6$), and the full-term group included 67 infants (31 boys, 36 girls) (Mage = 5.8 months, $SD = .6$). Sample retention at age of 12 months was 95%. The final sample at age of 12 months included 142 families: 80 families of preterm infant (Mage = 11.8 months, $SD = .6$) and 62 families of full-term infants (Mage = 11.7 months, $SD = .5$). Demographic information is detailed in Table 1. The preterm group was a demographically similar to a population-based cohort of preterm infants born in Israel in terms of parent's age, place of birth, and education level (The Gertner Institute Women and Children's Health Research Unit, 2012). No group differences were found in gender distribution, number of siblings, parents' age, and occupation or in maternal education. The majority of the parents in both groups were born in Israel. However, in the preterm group, there was a higher percentage of parents who were born in the former Soviet Union than in the full-term group (U = 2,184.5, $p < .001$; U = 2,323, $p < .01$, for mothers and fathers, respectively). Furthermore, fathers from the full-term group held higher educational qualifications than fathers from the preterm group ($U = 2{,}107.5$, $p < .05$).

Procedure

Subsequent to obtaining Helsinki Review Board approval, we invited families to participate in the study during their infants' postpartum hospitalization period, and 70% of those approached agreed to participate. The main reasons for refusal were time constraints and reluctance to be filmed. Those willing to participate signed consent forms. Data were collected in participating families' homes, when the infants were 6 and 12 months old, and at both time points, age was corrected for prematurity for the preterm group. When infants' were 6 months old, dyadic (mother–child; father–child) interactions were videotaped during free play. Following that, triadic (mother–father–child) interactions were videotaped during a semi-structured play session. Breaks between the interaction sessions were taken depending on infants' emotional states and parents' preferences. In addition, both parents reported on infants' temperamental characteristics. At the age of 12 months, infants' cognitive abilities were assessed.

Measures

Covariates

Infant medical risk at birth. The Nursery Neurobiological Risk Score (NBRS; Brazy, Eckerman, Oehler, Goldstein, & O'Rand, 1991) was used to assess preterm

TABLE 1
Demographic Information by Group

		Preterm group n = 80		*Full-term group n = 62*	
		Mothers	*Fathers*	*Mothers*	*Fathers*
Parental variables					
Age (years)	*M (SD)*	31.8 (5.5)	33.8 (6)	30.5 (4.9)	32.4 (5.4)
Country of origin	Israel	77.5% (62)	76.3% (61)	96.8% (60)	91.9 (57)
	Former Soviet Union	11.3% (9)	11.3% (9)	3.2% (2)	3.2% (2)
	Other	11.3% (9)	12.5% (10)	–	4.8% (3)
Education	Less than 12 years of studies	17% (14)	34.6% (28)	12% (8)	16.4% (11)
	High-school diploma	30% (25)	24% (20)	24% (16)	25.4% (17)
	College education	53% (44)	40.7% (33)	64% (43)	58.2% (39)
Occupation	Unemployed	14.5% (12)	10.8% (9)	23.9% (16)	4.5% (3)
	Unprofessional worker	6% (5)	7.2% (6)	–	9% (6)
	Professional worker	71% (59)	60% (50)	51% (34)	61.5% (41)
	Academic professional	7.2% (6)	18.1% (15)	25.4% (17)	22.4% (15)
Infant variables					
Number of siblings	*M* (*SD*)	1.63 (1.3)		1.45 (1.3)	
Gestational age (weeks)	*M* (*SD*)	32 (1.7)		39 (1.2)	
Birth weight (grams)	*M* (*SD*)	1,818 (475.8)		3,322.6 (426.8)	
Days of hospitalization	*M* (*SD*)	19.7 (13.8)		3 (1.3)	
Apgar score	*M* (*SD*)	9.3 (1.1)		10 (00)	

infants' medical risk. The NBRS includes seven items: infection, blood PH, seizures, intraventricular hemorrhage, assisted ventilation, periventricular variation, and hypoglycemia. Each item is assessed on a 5-point scale (0 = *no evidence,* 4 = *most severe condition*) by a trained research assistant, based on the infants' medical records. The total NBRS is the sum of the scores for each item, with higher scores indicating higher levels of medical risk. A cutoff score of 6 identifies infants at high risk for abnormal outcomes. The mean NBRS score for the preterm group in this study was 0.6 (*SD* = .97), with the range for all scores being 0–4, indicating that all infants were at low medical risk. The full-term group included healthy infants, all of whom scored 0 on the NBRS.

Infant medical risk at the age of 12 months. A medical risk index was created based on information obtained from the mothers when infants were 12 months old, regarding infants' hospitalizations and surgical procedures required since the initial discharge from the hospital. A score of 1 was given for each of the following situations: hospitalization up to 1 week; hospitalization over 1 week; and experiencing a surgical procedure. A medical risk index was computed as the sum of these three scores, ranging from 0 to 3, with higher scores representing more health complications. Preterm infants (M = .31, SD = .69) scored significantly higher than full-term infants (M = .10, SD = .39) on the medical risk index (t[148] = −2.30, p = .02).

Socioeconomic status (SES). A single SES composite was created using both parents' educational level and paternal occupational status. Principal components analysis (PCA) revealed that these three measures explained 63.5% of the variance. Therefore, these indicators were standardized and summed to create a single SES composite, with higher scores representing higher SES. No group differences were found in SES (t [135] = 1.89, *ns*).

Assessment at age 6 months

Parental structuring. To assess parental structuring, each parent (mothers and fathers separately) participated in a 7-min free-play interaction with the infant. Families were randomly assigned to begin with either the mother–infants interactions (50% of the cases) or the father–child interactions. The interaction took place in a quiet place in the home, and only the parent and the target child were present. Instructions were "play with your infant as you normally do." Parents were seated on the floor beside the infants, and a box of several age-appropriate soft toys including puppets, stuffed animals, stacking rings, soft blocks and soft musical pull toys was provided for parents to use during the interaction.

Coding—The interactions were coded using the fourth edition of the *Emotional Availability Scales* (EA; Biringen, 2008). EA is conceptualized as a bidirectional interactive construct. Each of the sub-scales was rated on a 7-point scale; higher scores indicate more positive behaviors. The current study used the *Parental Structuring* scale, which refers to the degree to which the parent appropriately structures the child's play, while setting limits when necessary. Optimal structuring represents parents who let the child lead the interaction while providing a supportive framework that is appropriate to the child's developmental stage and emotional state. Both verbal and nonverbal channels are used, and the parent sets limits and boundaries that are appropriate to the task and situation. Structuring attempts are successful, as they enable the child to move to a higher level of competence. Nonoptimal structuring represents parents who do not provide almost any guidance and appropriate leading. Structuring attempts may be repetitive and do not seem to influence the child or take the child's bids into account. The parent may engage in parallel play, but is not structuring per se. Limit-setting is likely to be absent.

Coding for both preterm and full-term infants was conducted by two trained coders who were blind to group belonging. The interactions were distributed between the coders so that different coders coded the same child while interacting with the mother and the father. Reliability was conducted for 15% of the tapes, and the intraclass correlation coefficient was .92.

Co-parental structuring. To assess co-parental structuring, the Lausanne Trilogue Play scenario (LPT; Fivaz-Depeursinge & Corboz-Warnery, 1999) was used. This semi-structured standardized observation scenario included various triadic situations among mothers, fathers, and infants. During the observation, parents were seated facing their infant, who was sitting in an infant seat. A box of age-appropriate soft toys was placed beside the parents. Parents were instructed to play together as a family and follow the directions for four separate parts of this activity: (1) one parent plays with the child, while the other parent will simply be present; (2) roles are reversed; (3) mother, father, and child play together; and (4) parents talk to each other, and the child is simply present. Parents were allowed to decide the length of each part of the activity, but were asked to limit the four parts to a combined 10 min, a duration appropriate to infants' young age. A stopwatch was provided so that parents could keep track of time.

Coding—The triadic interactions were coded according to the Family Alliance Assessment Scale (FAAS; Lavanchy-Scaiola, Favez, Tissot, & Frascarolo, 2008).The current study used the *Focalization* scale, which includes two criteria: co-construction and parental scaffolding. *Co-construction* refers to parents' ability to jointly structure the activity. A high score represents families in which parents cooperate in structuring joint activities, for example, by engaging in turn-taking, keeping the game going in a creative manner, and ensuring that the topic of the game is shared by all family members. A low score represents families, in which very few activities are shared by all three participants. Most of the time, activities are shared only within dyads (i.e., mother–child, father–child, or mother–father) or carried out individually. When a parent is in the "simply present" role, he seems aloof and uninterested in the activity carried out by the active dyad. *Parental scaffolding* refers to parents' appropriate provision of stimuli. A high score represents families in which parents provide a variety of stimulation that keeps the infant actively involved in the family activity. The provided stimuli are appropriate and respectful of the infant's developmental stage and emotional state. A low score refers to families in which parents provide over-stimulation and/or under-stimulation. The parents show difficulty adapting to the infant's state, and consequently, the infant disengages from the activity.

Each of the scale criteria was rated on a 3-point scale (0 = *inappropriate*; 1 = *moderate*; 2 = *appropriate*), and higher scores indicate more positive behaviors. Criterion scores were summed to calculate scale scores. Coding for both preterm and full-term infants was conducted by two trained coders who were blind to group belonging. Reliability was conducted for 15% of the tapes, and the intraclass correlation coefficient was .86.

Infant temperamental reactivity. The "fussy/difficult" scale from the Infant Characteristics Questionnaire (ICQ; Bates, Freeland, & Lounsbury, 1979) was used to assess infant temperament reactivity at the age of 6 months (e.g., "How easy or difficult is it for you to calm or soothe your baby when he/she is upset?). Mothers and fathers rated each item on a
7-point Likert scale ($\alpha = .81$ and $\alpha = .74$, for mothers and fathers, respectively). High scores indicate an easy temperament, whereas low scores reflect a difficult/reactive temperament style. Maternal and paternal reports were largely correlated ($r = .55$, $p < .001$); therefore, a reactive temperament composite score was created by averaging both parent's scores.

Assessment at age 12 months

Infant cognitive functioning. The cognitive scale from the third edition of the Bayley Scales of Infant Development (Bayley, 2006) was used to assess the infant's cognitive functioning. The Bayley scales are an individually administered instrument that assesses developmental functioning of infants and young children. The cognitive scale includes items assessing competencies such as exploration and manipulation, object relatedness, and memory. During assessment, the infant was seated at a table facing the experimenter. Depending on the infant's successful completion of a certain presented task, each item was rated on a 2-point scale (0 = *no successful completion;* 1 = *successful completion*). The cognitive assessments were administered by research assistants who were trained by a certified developmental psychologist to administer the Bayley assessment. The research assistants were blind to the 6-month interaction data as well as the birth status of the infants. The total cognitive scale raw score is the sum of all item scores. Norm-referenced composite scores, with scores of from 40 to 160, with a mean of 100 and a *SD* of 15, were calculated based on the norms provided by the publisher (Bayley, 2006).

Analytic strategy

The analytic strategy included three steps. First, preliminary analyses were conducted including evaluation of correlations between study variables and the control variables as well as correlations among all study variables for preterm and full-term infants. In addition, group differences in study variables were evaluated. Second, we examined whether birth status (preterm/full term) and temperamental reactivity moderated the association between parental structuring (maternal, paternal, and co-parental) and infants' cognitive functioning. To that aim, hierarchical linear regression was used (step 1: covariates; step 2: main effects; step 3: two-way interactions; step 4: three-way interaction) to predict infants' early cognitive functioning. Predictors that were included in statistical interaction terms were first centered. Interaction terms that were nonsignificant were trimmed from the analysis to achieve model parsimony. Significant two-way and three-way interactions were first probed for conditional values of the moderators (birth status and temperament). Then, the interactions were probed conditional upon the predicting parental structuring variable by estimating simple slopes at ± 2 *SD* of the parenting variable from the mean (Roisman et al., 2012), followed by regions of significance (RoS) analysis. The advantage of employing the RoS analysis is that these regions describe all possible values of the independent variable for which the regression is significant, instead of probing only two values (i.e., traditional simple slopes analyses, which refer only to two values, typically 1 *SD* above and below the mean), thus increasing the chances of identifying interactions that occur under either very poor or very beneficial environmental conditions (Kochanska, Kim, Barry, & Philibert, 2011). A differential susceptibility effect was inferred when the association between the moderator and the outcome was significant at both the low and high ends of the distribution of the parental structuring variable. A diathesis–stress model was inferred when the interaction was significant only on the low end of the distribution (Roisman et al., 2012).

Finally, to carry out a comprehensive examination of the differential susceptibility hypotheses, we also used an index for identifying differential susceptibility effects suggested by Roisman et al. (2012), namely the *Proportion of the Interaction* (PoI). The PoI expresses the proportion of the total interaction that is represented on the right side of the crossover point for the interaction (i.e., the area for which the effect of the independent variable on the dependent variable is "for better"). PoI values close to 0.50 suggest evidence for differential susceptibility, whereas values closer to 0 suggest evidence for diathesis–stress.

RESULTS

Preliminary analysis

Bivariate correlations between study variables and control variables were first estimated. Significant correlations were found between SES and several study variables including maternal structuring ($r = .29$, $p = .001$), paternal structuring ($r = .23$, $p = .008$), co-parental structuring ($r = .36$, $p < .001$), and infant cognitive score ($r = .28$, $p = .001$). Infant medical risk at birth was not significantly related to any of the study variables (r ranged between $r = .00$ and $r = .10$). However, infant medical risk score at 12 months of age was negatively related to maternal structuring ($r = -.17$, $p = .04$) and child cognitive score ($r = -.17$, $p = .03$). Thus, all analyses were conducted while controlling for SES and medical risk at age of 12 months. Next, a correlation matrix of the study variables for preterm and full-term infants was computed and group differences in study variables were examined (Table 2). As seen in Table 2, infants from the full-term group had significantly higher cognitive scores at

TABLE 2
Means, Standard Deviation, and Bivariate Correlations Between Study Variables Among Preterm and Full-term Infants

	1	*2*	*3*	*4*	*5*	*Univariate F*
M (*SD*)	30.64 (5.02)	5.55 (.86)	5.38 (.83)	1.78 (1.10)	108 (11.35)	
1. Temperament (6m)	–	−.02	.06	.16	.07	1.17
2. Maternal structuring (6m)	−.13	–	.42***	.28*	.24*	.54
3. Paternal structuring (6m)	.26*	−.20	–	.33*	.18	.26
4. Co-parental structuring (6m)	.02	.17	.18	–	.38***	1.33
5. Cognitive outcome (12m)	.00	.12	.05	.03	–	4.12*
M (*SD*)	31.50 (4.23)	5.78 (.80)	5.47 (.95)	1.73 (.94)	113.22 (11.31)	

Note. 6m = age 6 months; 12m = age 12 months.
Values above the diagonal represent correlations among the preterm group; whereas those below the diagonal represent correlations among the full-term group.
**p<.01, ***p≤.001.

age of 12 months than infants from the preterm group. No other group differences were found.

Regression analysis

All two-way and three-way interactions involving paternal structuring were nonsignificant; therefore, they were excluded from the analysis, and paternal structuring remained as a covariate. In addition, the two-way birth status by maternal structuring and three-way birth status by temperament by maternal structuring interactions were also nonsignificant and were therefore excluded from the analysis. The final regression model was significant, [$F(12, 119) = 4.72$, $p < .001$], accounting for 27.3% (adjusted R^2) of the variance in infants' cognitive outcomes (see Table 3). Two significant two-way interactions were detected: temperament by maternal structuring and temperament by co-parental structuring. The interaction between Birth status and co-parental structuring was significant on the third step, but only approached significance at the final step. In addition, the three-way interaction birth status by temperament by co-parental structuring was significant.

Probing two-way interactions

First, we probed the significant interaction between birth status and co-parental structuring from the third step of the regression analysis to examine the pattern of this interaction before taking into account the moderating role of temperament in the

TABLE 3
Hierarchical Regression for the Prediction of Infant Cognitive Outcome

Standardized regression weights	*Step 1: Covariates* β	*Step 2: Main effect* β	*Step 3: Two-way* β	*Step 4: Three-way* β
Step 1				
SES	.30**	.21*	.22*	.23*
Medical risk	−.15	−.11	−.10	−.10
Step 2				
Group		−.15	−.14	−.15
Temperament		.04	.10	.05
Paternal structuring		.05	.00	.00
Maternal structuring		.02	.00	.01
Co-parental structuring		.14	−.01	.02
Step 3				
Group X Temperament			−.08	−.04
Group X Co-parental structuring			.27*	.21^
Temperament X Co-parental structuring			−.09	−.33*
Temperament X Maternal structuring			−.29***	−.29***
Step 4				
Group X Temperament X Co-parental structuring				.29*
Adjusted R^2	.12***	.13***	.25***	.27***
F R^2 change	9.00***	1.37	5.40**	4.36*

Note. ^$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

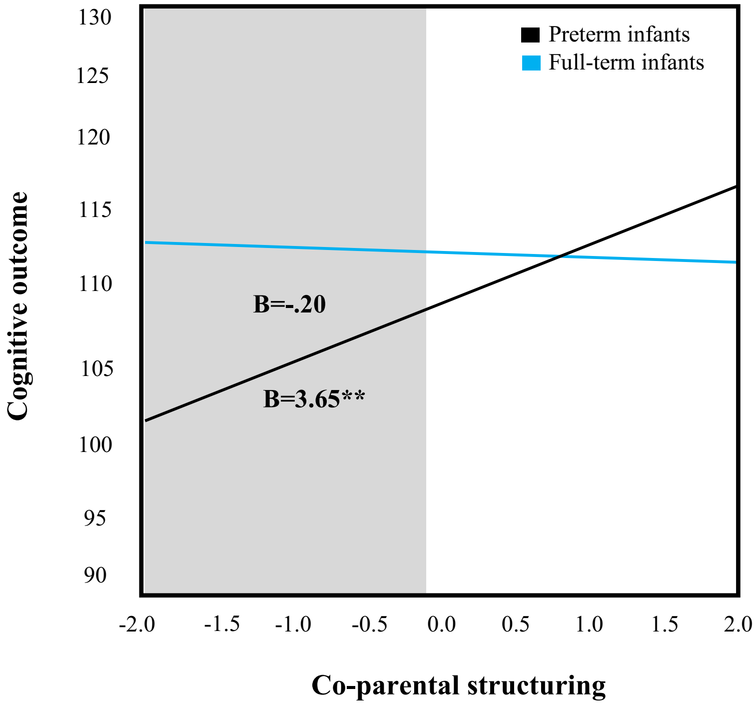

Figure 1 RoS analysis for the interaction between birth status and co-parental structuring on infants' cognitive functioning. The shaded area represents the RoS: The values of co-parental structuring for which group and infant cognitive functioning are significantly related.

fourth step. Simple slopes were estimated for preterm and full-term infants. The slope was significant for preterm infants (t[119] = 2.87, p = .005) but not for full-term infants (t[119] = .14, *ns*). Figure 1 shows the probed birth status by co-parental structuring interaction where the x axis shows parental structuring in *SD* units. Next, simple slopes for high (+2 *SD*) and low (−2 *SD*) levels of co-parental structuring were estimated, revealing that the association between group and cognitive functioning was significant under low levels of co-parental structuring (t[119] = 2.65, p = .009) but not under high levels of co-parental structuring (t[119] = 1.16, *ns*). Lower and upper bounds of the RoS of co-parental structuring were −.18 and 10.60, respectively. Thus, the two regression lines were significantly different when the score of co-parental structuring was lower than −.18 and higher than 10.60. The shaded area of Figure 1 represents the RoS, consistent with the diathesis–stress model. However, it should be noted that when preterm infants were exposed to higher levels of co-parental structuring (scores higher than −.18), their cognitive functioning was not different from full-term infants. PoI was less than .50 (.16), providing further evidence for a diathesis–stress effect.

Next, to probe the temperament by maternal structuring interaction, simple slopes were estimated for high (−1 *SD*) and average levels of reactive temperament. Figure 2 shows the probed temperament by maternal structuring interaction where the x axis shows parental structuring in *SD* units. The slope was significant for highly reactive infants (t[119] = −4.74, p = .008) but nonsignificant for infants with average temperamental reactivity (t[119] = .00, *ns*). Next, to ascertain whether this interaction was con-

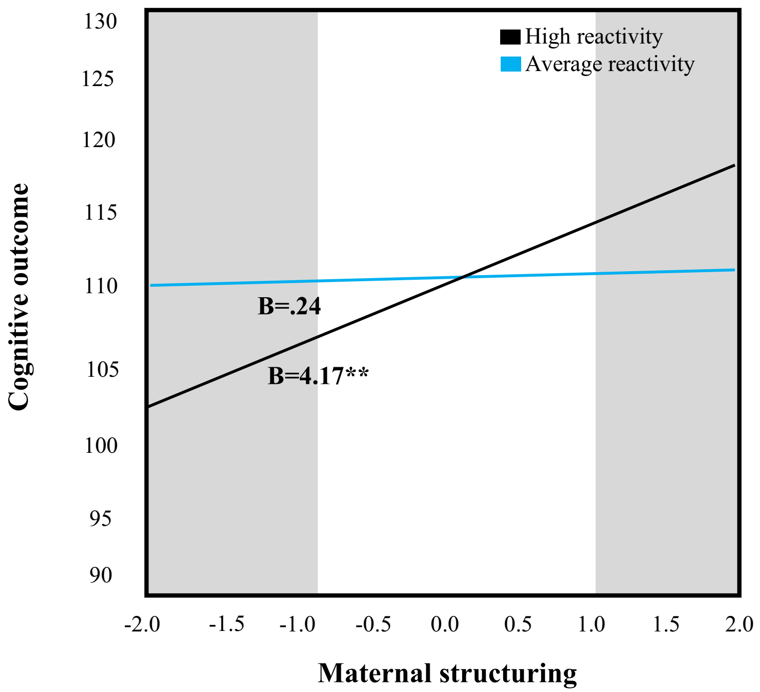

Figure 2 RoS analysis for the interaction between reactive temperament and maternal structuring on infants' cognitive functioning. The shaded area represents the RoS: The values of maternal structuring for which reactive temperament and infant cognitive functioning are significantly related.

sistent with differential susceptibility or diathesis–stress, simple slopes for high (+2 *SD*) and low (−2 *SD*) levels of maternal structuring were estimated revealing that the association between reactive temperament and cognitive functioning was significant under both low (t[119] = 2.96, p = .004) and high (t[119] = 2.98, p = .004) levels of maternal structuring. Lower and upper bounds of the RoS of co-parental structuring were −.81 and 1.04, respectively. Thus, the two regression lines were significantly different when the score of maternal structuring was higher than 1.04 or lower than −.81. The shaded area of Figure 1 represents the RoS, consistent with the differential susceptibility model. PoI was less than .43, providing further evidence for differential susceptibility.

Finally, to probe the temperament by co-parental structuring interaction, simple slopes were estimated for high (−1 *SD*) and average levels of reactive temperament. The slope approached significance for highly reactive infants (t[119] = 1.73, p = .08) and was nonsignificant for infants with average reactivity (t[119] = .18, *ns*). Because the slope for highly reactive infants only approached significance, no further probing was applied.

Probing the three-way interaction

The significant birth status by temperament by co-parental structuring three-way interaction was probed for simple slopes at conditional values of the moderators [i.e., birth status (preterm/full term) and temperament (high (−1 *SD*) and average levels of reactive temperament]. The positive link between co-parental structuring and infants' cognitive outcomes was significant for preterm infants with average temperamental reactivity ($t[119] = 2.76$, $p = .006$) and full-term infants with high temperamental reactivity ($t[119] = 1.98$, $p = .04$), but nonsignificant for all other subgroups of infants. These findings imply that infants who carry one susceptibility factor (i.e., premature birth or reactive temperament) show similar patterns of susceptibility to co-parental structuring.

DISCUSSION

The main goal of this study was to examine the interactions between two child susceptibility factors: prematurity and reactive temperament and parenting in early cognitive development. Results indicated that both prematurity and reactive temperament acted as a susceptibility factors to parenting. Preterm infants were more strongly affected by co-parental structuring in their cognitive functioning than full-term infants. However, temperament further moderated these associations. Furthermore, infants with reactive temperaments were more strongly affected by maternal structuring behaviors. Both diathesis–stress and differential susceptibility effects were evident.

Prematurity as a susceptibility factor

Consistent with the broad literature on preterm infants' cognitive vulnerability (e.g., Aylward, 2005), we found that preterm infants performed significantly lower than full-term infants on the 12-month cognitive assessment. However, this cognitive disadvantage disappeared when they were exposed to a high-structuring co-parental environment. Preterm infants' heightened malleability to parenting may actually reflect neurobiological susceptibility (Ellis et al., 2011). Prematurity has been associated with the underdevelopment of the autonomic nervous system (ANS; De Rogalski Landrot et al., 2007), which may result in difficulties in processing external stimuli, inappropriate adaption to stress, and regulatory difficulties (Feldman & Eidelman, 2007; Grunau et al., 2007; Woodward et al., 2011). Due to their poor regulatory capacities, preterm infants may strongly rely on the external regulation provided within early parenting contexts and thus be more strongly affected by these contexts than infants who carry low neurobiological susceptibility.

Contrary to our hypothesis, this pattern of results was consistent with the diathesis–stress model (Monroe & Simons, 1991) for understanding person × environment interactions, rather than the differential susceptibility model (Belsky, 2005; Ellis et al., 2011). These findings corroborate recent examinations of prematurity or LBW as susceptibility factors to parenting in cognitive development (Jaekel et al., 2015; Gueron-Sela et al., 2015), which also indicated similar diathesis–stress effects. One reason for the emergence of these diathesis–stress effects may be that prematurity and LBW are often associated with initial abruptions in the development of the prefrontal cortex (Pickler et al., 2010), which may result in difficulties in core cognitive abilities (e.g., lower working memory, inhibition, and planning abilities; Sun, Mohay, & O'Callaghan, 2009). Thus, preterm infants' initial neurological risk may set an upper threshold to the degree by which a supportive environment can enhance cognitive abilities.

Moreover, temperamental reactivity further moderated preterm infants' susceptibility to parental structuring. Specifically, infants who carried one susceptibility factor (i.e., premature birth or reactive temperament) showed similar patterns of susceptibility to co-parental structuring. However, infants who carried either two susceptibility factors (i.e., preterm infants with reactive temperaments) or no susceptibility factors (i.e., full-term infants without reactive temperaments) were not affected by co-parental structuring. Our findings imply that child susceptibly factors may not simply act in a cumulative linear manner. The presence of two potential susceptibility factors (i.e., premature birth and temperamental reactivity) actually resulted in lower, rather than higher, malleability to parenting. These findings are not in line with previous reports of heightened susceptibility to parenting in cognitive development among preterm infants who are prone to distress (Poehlmann et al., 2012). This contrasting pattern of results may be attributed to the different parenting behaviors assessed in both studies. Poehlmann et al. (2012) focused on emotional aspects of parental behaviors, such as positive affect and connectedness, which may be particularly beneficial for children who experience high levels of distress (e.g., Klein Velderman, Bakermans-Kranenburg, Juffer, & van IJzendoorn, 2006). We, however, focused on parental structuring behaviors that may not be advantageous for children who experience dual risk (i.e., premature birth and reactive temperament). These children may be characterized by poor attention and executive function capacities, which are associated with prematurity, combined with heightened negative emotionality, which seems to reduce their capacity to be negatively affected or to benefit from parental behavior.

Parental structuring and infants' cognitive functioning

A novel aspect of this study was the examination of the effects of maternal, paternal, and co-parental parenting on early infant development. Consistent with previous research on the differential susceptibility hypothesis that focused on maternal caregiving behaviors (Poehlmann et al., 2012; Roisman et al., 2012), we found that maternal structuring behaviors at age of 6 months were related to infants' cognitive functioning at age of 12 months, but only among highly reactive infants, and not for infants with average temperamental reactivity. This pattern of results was consistent with the differential susceptibility hypothesis. Our findings further suggest that the co-parental context has a significant contribution to infants' emerging cognitive abilities, over and above maternal and paternal individual behaviors with the child. Previous studies examining the effects of co-parenting on academic or cognitive outcomes highlighted negative aspects of co-parenting, such as conflict and hostility (Cabrera et al., 2012; Karreman et al., 2008). In the current study, we focused on positive co-parenting behaviors that actively support early cognitive development: co-parental structuring. There are two possible mechanisms by which co-parental structuring may promote children's cognitive development. The first is a direct mechanism: the provision of appropriate stimuli and guidance that is respectful of the infant's cues and developmental stage and helps the child organize and execute his/her goal-directed activities and exploration (Bibok, Carpendale, & Müller, 2009). Consequently, parents facilitate cognitive development by setting a context in which infants gradually master those functions themselves (Bibok et al., 2009). The second mechanism refers to children's emotional security within the family (Cummings & Davies, 2010). Cooperative co-parenting behaviors may contribute to children's sense of emotional security and confidence in the responsiveness of their parents (Cummings & Davies, 2010). This sense of security enables the infant to use his or her parents as a secure base from which to explore the world, promoting cognitive development (Ainsworth, 1985).

Overall, paternal structuring did not significantly contribute to the variance in infants' cognitive outcomes. These results imply that the role of paternal structuring in cognitive development may be relatively small when taking into account co-parental structuring. The increasing levels of paternal involvement and engagement in infant care seen in the past decade (Goodman, 2005) may explain the salience of the co-parental context that was evident in our findings.

Limitations and future research

Several limitations should be noted in the present study. First, infant temperament was assessed using parental reports. Although we used a composite of both parents' reports, including laboratory observations of infants' temperament would have resulted in a more comprehensive temperamental assessment. Second, aside from controlling for infants' medical risk level, the study did not control for infants' physiological functioning. For example, neurobiological stress reactivity (i.e., respiratory sinus arrhythmia and salivary cortisol responses) has been found to moderate the effects of parenting on children's developmental outcomes (Obradovic, Bush, Stamperdahl, Adler, & Boyce, 2010). Including such measures could have revealed the role of infant physiological regulation to the process of early cognitive development. Third, we specifically focused on parental structuring behaviors. Examining these processes while looking at additional aspects of parent–child interactions, such as warmth, may provide a more comprehensive understanding of the role of family dynamics in early development. Finally, this study focused on early development of preterm infants living in Israel at low medical risk. Replications with preterm groups at varied levels of medical risk and older ages are needed to understand long-term susceptibility to parenting among preterm infants at varying degrees of medical risk. Furthermore, the cultural context of this study should be taken into account. In the current study, premature birth was not associated with environmental risk factors. However, research suggests that in some western cultures, factors such as poverty, limited maternal education, young maternal age, unmarried status, and race are often associated with increased risk for preterm birth (Mugila & Katz, 2010). Under high environmental risk, the role of co-parental relationships may be different. Therefore, it is important to examine these processes in additional cultural groups as well as in high environmental risk groups in Israel, before it can be generalized.

CONCLUSIONS AND IMPLICATIONS

Despite the limitations stated above, results from this study highlight the importance of taking a wide systemic approach to understanding the process by which child characteristics interact with parent–child relationships during infant development. Focusing only on one child factor or a single relationship context may result in a narrow, incomprehensive understanding of this process. Furthermore, these results have important clinical implications for the type of follow-up care and anticipatory guidance provided to families of preterm infants. Currently, most child development centers implement infant-focused interventions for enhancing cognitive abilities. Results from the current study reflect the need to expand the focus of intervention to the co-parental level. Professional guidance should be given to parents on how to enhance their abilities to work together as a team to provide appropriate structuring and guidance that will support their children's cognitive development.

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