

Preterm infants who are prone to distress: differential effects of parenting on 36-month behavioral and cognitive outcomes

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Background: The differential susceptibility (DS) model suggests that temperamentally prone-to-distress infants may exhibit adverse outcomes in negative environments but optimal outcomes in positive environments. This study explored temperament, parenting, and 36-month cognition and behavior in preterm infants using the DS model. We hypothesized that temperamentally prone to distress preterm infants would exhibit more optimal cognition and fewer behavior problems when early parenting was positive; and less optimal cognition and more behavior problems when early parenting was less positive. **Methods:** Participants included 109 preterm infants (gestation <37 weeks) and their mothers. We assessed neonatal risk and basal vagal tone in the neonatal intensive care unit; infant temperament and parenting interactions at 9 months post-term; and child behavior and cognitive skills at 36 months post-term. Hierarchical regression analyses tested study hypotheses. **Results:** Temperamentally prone-to-distress infants exhibited more externalizing problems if they experienced more critical parenting at 9 months ($\beta = -.20, p < 0.05$) but fewer externalizing problems with more positive parenting. Similarly, variations in maternal positive affect ($\beta = .25, p < .01$) and intrusive behaviors ($\beta = .23, p < .05$) at 9 months predicted 36-month cognition at high but not at low levels of infant temperamental distress. Higher basal vagal tone predicted fewer externalizing problems ($\beta = -.19, p < .05$). **Conclusions:** Early parenting behaviors relate to later behavior and development in preterm infants who are temperamentally prone to distress, and neonatal basal vagal tone predicts subsequent externalizing behaviors. These findings suggest that both biological reactivity and quality of caregiving are important predictors for later outcomes in preterm infants and may be considered as foci for developmental surveillance and interventions. **Keywords:** Behavior, IQ, vagal tone, parenting, preterm, temperament.

Introduction

Even in the absence of neurodevelopmental disability, preterm infants exhibit less optimal cognitive abilities and more behavior problems, on average, than full-term infants (Rose, Feldman, Rose, Wallace, & McCarton, 1992). Although preterm infants who experience more responsive and sensitive early parenting exhibit better cognitive and social outcomes compared with preterm infants who experience less optimal parenting (Landry, Smith, Miller-Loncar, & Swank, 1997; Laucht, Esser, & Schmidt, 2001; Smith, Landry, & Swank, 2006), we do not know how individual differences in infant temperament interact with parenting to predict outcomes in preterm infants. Do certain infant characteristics render preterm infants more susceptible to the effects of parenting?

Temperament, an infant characteristic described as a moderately stable constellation of biologically based behavioral traits, exerts effects on personality and behavior (Rothbart & Bates, 2006). In full-term infants, temperament characteristics such as negative emotionality predict later behavior problems and poorer cognitive skills (Blair, 2002; Lawson & Ruff,

2004; Shah, Owens, Vondra, Keenan, & Winslow, 1996). In preterm infants, the temperament characteristic of *proneness to distress* predicts poorer cognition and more behavior problems (Ross, 1987), with variations in parenting predicting 24-month externalizing behaviors in more temperamentally distressed infants (Poehlmann et al., 2011). This suggests that the effects of parenting on infant outcomes may differ depending on infant temperament, but little is known about such interactions in preterm infants.

Early physiological reactivity or regulation, a characteristic related to temperament, is thought to be an important factor for both preterm and full-term infants (Feldman, 2009). Compared with healthy full-term infants, preterm infants are at risk for physiological dysregulation, reflected in lower heart rate variability (HRV) (Longin, Gerstner, Schaible, Lenz, & König, 2006). HRV measures capture fluctuations in intervals between consecutive heartbeats and instantaneous heart rates (Task Force of the European Society of Cardiology & the North American Society of Pacing and Electrophysiology, 1996). During rest, changes in heart rate intervals depend largely on modulation by parasympathetic nervous system (PSNS) fibers in the vagus nerve, and thus PSNS

Conflict of interest statement: The authors have declared that they have no competing or potential conflicts of interest.

influences, or basal vagal tone, prevails. In preterm children, higher vagal tone has been associated with fewer behavior problems, (Feldman, 2009) and with more optimal mother-child co-regulation (Porter, 2003). Some scholars have linked HRV with infant temperament (Rothbart & Bates, 2006).

The differential susceptibility (DS) model (Belsky, 1997) suggests that temperamentally reactive (easily frustrated or prone to distress) infants who experience *suboptimal* environments are at risk for developing *problematic* social outcomes, and conversely, temperamentally reactive infants who experience *positive* environments are likely to experience *optimal* outcomes. In this model, temperamental reactivity functions not as a risk, but rather as a susceptibility factor, whereby the effects of emotional reactivity on later outcomes are influenced by caregiving quality, for better or worse (Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2007). Variations in susceptibility are theorized to have an evolutionary basis; through natural selection, human beings disperse genes to subsequent generations that most positively influence reproductive fitness. Not knowing what characteristics are optimal for later adaptation, parents pass on traits that vary in susceptibility to rearing influence, thereby increasing the chance that children have biological characteristics that optimize their chances for survival, adaptation, and reproduction (Belsky, 2005). Although the DS model has primarily been tested on social behavior outcomes, infant cognition may be similarly susceptible to caregiving variations, as cognitive skills may play a role in adaptation and reproductive success. At a time when survival related to deterring or escaping predators, better cognitive skills could offer an evolutionary advantage to an organism's adaptation and survival.

In full-term children, a growing body of evidence supports the DS model, especially for externalizing behaviors (Belsky, Hsieh, & Crnic, 1998; Klein-Velderman, Bakermans-Kranenburg, Juffer, & van IJzendoorn, 2006; Bradley & Corwyn, 2007; Cassidy, Woodhouse, Sherman, Stupica, & Lejuez, 2011; Bakermans-Kranenburg & van IJzendoorn, 2011). We explored the possibility that in preterm infants, effects of parenting on behavior and cognition may also vary depending on infant reactivity (i.e., proneness to distress and basal vagal tone), hypothesizing that preterm infants who were prone to distress (or had lower basal vagal tone) would be differentially susceptible to parenting. We use the term 'proneness to distress' rather than negative emotionality or irritability to describe preterm infants who become easily and sometimes intensely distressed, whether by fear, anger, or sadness.

Because neonatal medical and socioeconomic risk and maternal depressive symptoms can affect parenting and outcomes in preterm infants (e.g., Poehlmann et al., 2011), and because mothers with elevated depressive symptoms may rate their

children's behaviors more negatively than other mothers (Fergusson, Lynskey, & Horwood, 1993), we controlled for these variables in our analyses.

Methods

Participants

Participants included 109 infants from a larger study (citation removed) who were preterm (<37 weeks gestation) and had 36-month visits and HRV measures. For the larger study, 181 infants were recruited from three Wisconsin Neonatal Intensive Care Units (NICUs) from 2002 to 2005 if infants: (a) were <2500 g at birth OR <37 weeks gestation, (b) had no congenital or significant neurological problems or prenatal drug exposures based on hospital screening; and if mothers were (c) >17 years of age, (d) could read English, and (e) self-identified as primary caregiver. For multiple births, one infant was randomly selected.

Race/ethnicity distribution of infants was 72% White, 15% multiracial, 12% Black, and 1% Latino, similar to the US population (72% White, 3% multiracial, 13% Black, 16% Hispanic), with a slightly higher representation of multiracial and lower representation of Latino infants (U.S. Census Bureau, 2011). Gestational age ranged from 23.71 to 36.43 weeks ($M = 31.7$, $SD = 3.1$) and birthweight ranged from 564–3328 g ($M = 1773.7$ g, $SD = 598.4$). Hospitalization lasted an average of 32.1 days ($SD = 29.0$). At NICU discharge, mothers, on average, were 30.3 years ($SD = 6.2$) and completed 14.6 years of education ($SD = 2.5$). Most of the mothers (73%) were married, and mean family income was \$63,107.

Attrition was 17% between hospital discharge and 36 months, with no differences in infant health, family income, number of children, paternal age, or maternal race/ethnicity. Mothers lost to attrition were younger and more likely to be single, and fathers had lower education and more socio-demographic risks than families who continued participating.

Procedure

Following Institutional Review Board (IRB) approval, infants were assessed six times between the NICU and 36-months corrected age (calculated from the infant's due date; DiPietro & Allen, 1991). This report focused on NICU, 9- and 36-month data. Nurses told eligible participants about the study and obtained informed consent from mothers. Just before NICU discharge, infant medical records were reviewed, mothers completed demographic forms, and infant HRV was measured. The 9-month home visit included videotaping 15 min of infant-mother play and assessment of maternal depression and infant temperament. At 36 months, children visited a laboratory and participated in cognitive assessments while mothers completed forms. Participants were paid \$40 at 9-months and \$85 at 36-months.

Measures

Controls. *Neonatal health.* A neonatal health risk index was created from review of NICU medical records.

Infant gestational age and birthweight were standardized, reverse-scored, and combined with the standardized sum of the presence of ten neonatal medical risks (% infants experiencing in parentheses): apnea (72.5%), respiratory distress (56.9%), chronic lung disease (11%), gastroesophageal reflux (9.2%), multiple birth (21.1%), supplementary oxygen at NICU discharge (9.2%), apnea monitor at NICU discharge (41.3%), 5-min Apgar score <6 (.9%), ventilation during NICU stay (52.3%), and NICU stay >30 days (36.7%). The index had a Cronbach's α of .72, similar to previous studies (e.g., Shah, Clements, & Poehlmann, 2011), with higher scores reflecting more prematurity and health risks (Table 1 presents means and SDs).

SES risk. A socioeconomic (SES) risk index was created by summing the presence of the following risks identified from the demographic questionnaire: income below federal poverty guidelines for family size, both parents unemployed, single mother, adolescent mother, >4 children, mother or father less than high school graduate. Scores ranged from 0 to 7, with higher scores reflecting more risks ($\alpha = .75$), similar to previously studies (Poehlmann et al., 2011).

Maternal depressive symptoms. Mothers completed the Center for Epidemiologic Studies–Depression Scale (CES-D) (Radloff, 1977), a well-validated 20-item questionnaire, responding on a 4-point scale, rarely/none of the time (0) to most/all of the time (3), during the past week. Scores range from 0 to 60 ($\alpha = .88$). Sample reliability was similar to previous reliability ($\alpha = .85$) (Radloff, 1977).

Predictors. Temperament. Tasks from the Laboratory Assessment of Temperament (LAB-TAB) (Goldsmith & Rothbart, 1996), a widely-used observational assessment, were administered at 9 months and coded in 10-s intervals by three coders ($\kappa = .89-.92$): Unpredictable Dog: intensity of vocal distress and fear; Plastic Barrier: vocal distress, facial and bodily sadness, latency

to anger; Colored Block: latency to look away, duration of orienting and manipulating the toy. A principal components analysis was conducted to reduce data and two components emerged, labeled *Distress* (four items, $\alpha = .80$) and *Attention* (three items, $\alpha = .62$). Factor loadings ranged from .66 to .90, with no overlap, although anger latency and fear intensity did not load on either factor. For this study, we used the Distress component ($\alpha = .80$), with higher scores indicating more proneness to distress. Internal consistency on LAB-TAB measures of negative emotions ranges from .80 to .93 (Gagne, Van Hulle, Aksan, Essex, & Goldsmith, 2011). Ten children (9%) had missing LAB-TAB data because of equipment failure or fussiness.

Vagal tone. At HRV data collection, infants ranged from 32 to 44 postconception weeks ($M = 36$, $SD = 1.78$), although assessment timing was unrelated to HRV. HRV was recorded during 10 min of resting before feeding, a timeframe recommended by Longin et al. (2006), using a two-channel ambulatory ECG (electrocardiogram) Holter recorder and analyzed using power spectrum analysis (PSA) with fast Fourier transform (FFT). Analysis details were recently published (citation removed). PSA quantifies components in terms of power within specified frequency bandwidths. FFT provides a spectral density plot of high (HF) and low (LF) frequency power as a function of heart rate. Spectral activity is expressed as absolute power (milliseconds²) in HF and LF bands (Goldsmith & Rothbart, 1996); PSNS influences are seen in the HF range (Task Force of the European Society of Cardiology & the North American Society of Pacing and Electrophysiology, 1996; Beauchaine, 2001).

Mean HF power was computed to assess basal vagal tone. Nine (8%) children did not have usable HRV tapes because of equipment problems; 16 (15%) prefeeding recordings did not last 10 full minutes because of infant hunger, so observations were coded as missing.

Table 1 Bivariate correlations and descriptive statistics for key variables

Variable	1	2	3	4	5	6	7	8	9	10	11
1. SES risk	–										
2. Neonatal risk	.06	–									
3. CES-D	.42**	.13	–								
4. PCERA-1	–.31**	.01	–.21*	–							
5. PCERA-2	–.26**	.05	–.28**	.73**	–						
6. PCERA-3	–.19	–.05	–.30**	.58**	.82**	–					
7. Proneness to distress	–.02	.03	.02	.03	.04	–.07	–				
8. Vagal tone	–.09	–.33**	–.01	.07	.09	.21	–.03	–			
9. CBCL externalizing	.15	–.18	.36**	–.00	–.11	–.17	.05	–.07	–		
10. CBCL internalizing	.16	–.18	.38**	–.08	–.14	–.18	.02	–.02	.64**	–	
11. ABIQ	–.42**	–.07	–.26**	.27**	.23*	.20*	–.03	.12	–.09	.00	–
<i>M</i>	0.87	–0.20	9.08	3.68	3.65	3.99	–0.11	3.45	52.46	50.80	95.93
<i>SD</i>	1.42	2.75	8.21	0.73	0.69	0.74	0.66	0.87	9.06	10.35	14.00
Min–Max values	0–5	–4.7–6.5	0–43	1.9–4.9	2.0–4.8	1.4–5.0	–0.5–2.9	1.8–5.5	28–70	29–72	52–130

ABIQ, abbreviated battery intelligence quotient; CES-D, Center for Epidemiological Studies–Depression; PCERA-1, *Communication, Positive Affect, Connectedness*; PCERA-2, *Intrusiveness, Anxiety, Insensitivity*; PCERA-3, *Frustration, Hostility, Criticism*; SES risk, socioeconomic risk.

** $p < .01$, * $p < .05$.

Parenting interactions. Nine-month parenting was coded with 29 parenting variables of the Parent Child Early Relational Assessment (PCERA) (Clark, 1999), an observational coding system appropriate for preterm infants that has high internal consistency (.75–.96) and validity (Pridham, Steward, Thoyre, Brown, & Brown, 2007). Variables are coded on a 1 (negative quality) to 5 (positive quality) scale. An exploratory factor analysis was conducted with a three-factor solution, similar to previous research (Clark, 1999), and labeled as *Positive Affect, Communication, and Connectedness* (PCERA-1; 14 items, $\alpha = .95$), *Intrusiveness, Anxiety and Insensitivity* (PCERA-2; eight items, $\alpha = .89$), and *Frustration, Hostility and Criticism* (PCERA-3; five items, $\alpha = .93$). Higher scores reflected more positive parenting; for PCERA-2 and PCERA-3, lower scores represented more intrusiveness and frustration. Two trained researchers, blind to other data, coded 10% of randomly-selected tapes independently. Mean interrater reliability was .88 (range .83–.97), similar to prior studies (Clark, Hyde, Essex, & Klein, 1997). Kappas for individual codes ranged from .60 to 1.0 ($M = .83$).

Child outcomes. Behavior problems. Mothers completed the Child Behavior Checklist (CBCL 1½–5) (Achenbach & Rescorla, 2000) at 36 months. The CBCL is standardized, with items rated on a 3-point scale, not true (0) to very or often true (2), regarding behaviors occurring during the past 2 months. T-scores, calculated from age and gender norms, were used for the Externalizing and Internalizing scales. The CBCL has been used with preterm infants (Yu, Buka, McCormick, Fitzmaurice, & Indurkha, 2006), and has high internal consistency ($\alpha = .78$ –.97), similar to the present study ($\alpha = .85$ –.91). One mother (1%) did not finish the CBCL, so 108 checklists were available. In this sample, 23 (21%) children showed significant externalizing problems (T-scores >60), whereas 22 (20%) children exhibited significant internalizing problems, similar to previously reported rates (20%) in preterm children (Gray, Indurkha, & McCormick, 2004).

Cognitive skills. Child cognition at 36 months was estimated using the Abbreviated Battery scale (ABIQ) from the Stanford-Binet Intelligence Scales, 5th edition (Roid, 2003), administered by a trained graduate student supervised by a licensed psychologist. This standardized assessment for children 2 years to adulthood reports cognitive skills as standard scores, with a mean of 100 ($SD = 15$), and demonstrates high reliability ($\alpha = .90$), and high correlation with full-battery IQ scores (Roid, 2003). The ABIQ is the sum of the Nonverbal Fluid Reasoning ($\alpha = .81$) and Verbal Knowledge ($\alpha = .93$) scaled scores. ABIQ scores were available for 104 children. In this sample, seven (7%) children had IQ scores that were <70. Children with ABIQ <70 were retained in hypothesis tests, but results were equivalent if excluded.

Results

Plan of analysis

Data were analyzed using PASW Statistics (v.17.0; SPSS, Chicago, IL). As noted, some variables had missing values (4% overall). To address this issue, a multiple imputation procedure (Raghunathan, Lep-

kowski, van Hoewyk, & Solenberger, 2001; Schafer, 1997; Van Buuren, 2007) was implemented, involving generating five datasets in which missing values were randomly produced conditional upon other variables in the analysis. Subsequent analyses were applied to all five datasets, with aggregated results reported. (Findings were similar in the original and aggregated data sets). Outcome variables were not imputed.

Following data screening, we followed the steps to test DS recommended by Belsky et al. (2007), using separate hierarchical regression analyses for each outcome and PCERA factor. This approach resulted in nine analyses for the test of temperament susceptibility and nine analyses for the test of HRV. Controls were entered in the first step (neonatal risk, SES risk, CES-D), main effects of Distress and the PCERA in the second step, and the Distress X PCERA interaction (created with centered variables, Aiken & West, 1991) in the third step. As recommended by Belsky et al. (2007), when an interaction term was statistically significant, we performed post hoc analyses (simple regressions examining parenting slopes at +1 *SD* the mean of Distress; Cohen, Cohen, West, & Aiken, 2003) to determine differential effects of parenting on outcomes (behavior and ABIQ) based on proneness to distress, per Belsky et al. (2007). Results of significant interactions are presented graphically (Figure 1) and compared with prototypical graphs (Belsky et al., 2007). To assess the independence of susceptibility and parenting factors, we also examined bivariate correlations (Table 1). Tables 2–4 contain results for significant effects.

Infant proneness to distress and child outcomes

36-month behavior problems. Neither positive (PCERA-1), intrusive (PCERA-2), frustrated (PCERA-3) interactions, nor infant proneness to distress predicted child externalizing problems. Although no main effects were seen, the Distress X PCERA-3 (frustrated parenting) interaction significantly predicted 36-month externalizing problems. (Table 2) Post hoc tests indicated that at high levels of infant proneness to distress, variations in maternal frustration and critical parenting significantly predicted child externalizing problems, $\beta = -.38$, $p < .01$, whereas such parenting did not predict externalizing problems at low levels of infant distress, $\beta = .07$, $p = .28$. Infants who were temperamentally prone to distress exhibited more externalizing problems at 36 months when mothers exhibited more frustration, anger, and criticism toward their infants at 9 months, although children exhibited fewer 36-month externalizing problems when parenting interactions were more optimal, consistent with the DS model (Figure 1A). There were no significant interaction effects between Distress and PCERA-1 (positive parenting) or between Distress and PCERA-2

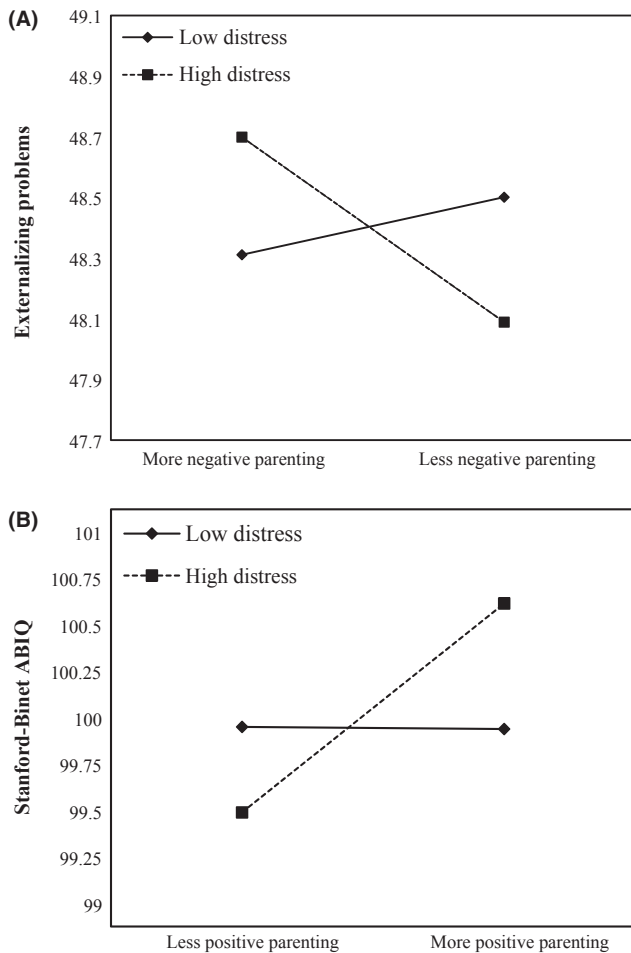


Figure 1 Differential effects of parenting on 36 month outcomes. (A) Proneness to distress and parenting (PCERA-3: *Frustration, Hostility, Criticism*) predict children’s externalizing behavior problems at 36 months. More negative parenting less negative parenting. (B) Proneness to distress and parenting (PCERA-1: *Communication, Positive Affect, Connectedness*) predict children’s cognitive skills at 36 months

Table 2 Regression analyses: infant distress X PCERA-3 predicting 36-month CBCL externalizing behavior problems

Step predictor	Beta	t	Sig.
1			
Neonatal risk	-.263	-2.437	.015
SES risk	-.077	-0.212	.832
CES-D	.437	3.906	.000
2			
Neonatal risk	-.264	-2.443	.015
SES risk	-.090	-0.291	.771
CES-D	.418	3.616	.000
Proneness to distress	.042	0.578	.564
PCERA-3	-.090	-0.813	.416
3			
Neonatal risk	-.273	-2.647	.008
SES risk	-.096	-0.398	.691
CES-D	.440	3.949	.000
Proneness to distress	-.006	-0.011	.992
PCERA-3	-.105	-1.097	.273
Distress X PCERA-3	-.200	-2.142	.035

CES-D, Center for Epidemiological Studies-Depression; PCERA-3, *Frustration, Hostility, Criticism* SES risk, socioeconomic risk.

Table 3 Regression analyses: infant distress X PCERA-1 predicting 36-month ABIQ

Step Predictor	Beta	t	Sig.
1			
Neonatal risk	-.018	-0.398	.690
SES risk	-.383	-3.767	.000
CES-D	-.166	-0.943	.345
2			
Neonatal risk	-.023	-0.488	.625
SES risk	-.336	-3.355	.001
CES-D	-.152	-0.753	.452
Proneness to distress	-.001	-0.015	.988
PCERA-1	.185	1.747	.081
3			
Neonatal risk	-.028	-0.519	.604
SES risk	-.324	-3.393	.001
CES-D	-.155	-0.899	.369
Proneness to distress	.048	0.521	.604
PCERA-1	.248	2.413	.016
Distress X PCERA-1	.253	2.878	.004

ABIQ, abbreviated battery intelligence quotient; CES-D, Center for Epidemiological Studies-Depression; PCERA-2 *Intrusiveness, Anxiety, Insensitivity*; SES risk, socioeconomic risk.

Table 4 Regression analyses: infant distress X PCERA-2 predicting 36-month ABIQ

Step predictor	Beta	t	Sig.
1			
Neonatal risk	-.018	-0.398	.690
SES risk	-.383	-3.767	.000
CES-D	-.166	-0.943	.345
2			
Neonatal risk	-.032	-0.546	.585
SES risk	-.356	-3.551	.000
CES-D	-.136	-0.633	.527
Proneness to distress	-.005	-0.034	.973
PCERA-2	.156	1.376	.169
3			
Neonatal risk	-.036	-0.570	.569
SES risk	-.316	-3.156	.002
CES-D	-.170	-1.066	.286
Proneness to distress	.047	0.540	.590
PCERA-2	.206	1.959	.050
Distress X PCERA-2	.229	2.559	.011

ABIQ, abbreviated battery intelligence quotient; CES-D, Center for Epidemiological Studies-Depression; PCERA-2 *Intrusiveness, Anxiety, Insensitivity*; SES Risk, socioeconomic risk.

(intrusive parenting) on 36-month externalizing behavior outcomes.

There were no main or interaction effects for the three PCERA factors or Distress in predicting 36-month internalizing problems.

36-month cognitive skills. Neither positive (PCERA-1), intrusive (PCERA-2), frustrated (PCERA-3) parenting interactions, nor infant proneness to distress predicted infant cognition. Although no main effects were seen, regression analyses demonstrated that infant proneness to distress, *in combination with* certain parenting styles, predicted child cognition at 36 months. Distress X PCERA-1 (positive parenting)

and Distress X PCERA-2 (intrusive and insensitive) interactions significantly predicted 36-month ABIQ (Tables 3 and 4) at 36 months.

Post hoc tests indicated that at high levels of infant proneness to distress, variations in maternal communication and positive affect (PCERA-1) at 9 months significantly predicted ABIQ at 36 months, $\beta = .71$, $p < .001$, but not at low levels of infant distress, $\beta = .17$, $p = .20$. More easily distressed infants exhibited higher cognitive skills at 36 months when mothers exhibited more communication, positive affect, and connectedness during interactions at 9 months and lower 36-month cognitive skills when 9-month interactions were less optimal (Figure 1B).

Similarly, post hoc tests indicated that at high levels of infant proneness to distress, less maternal intrusiveness and insensitivity (PCERA-2) related to higher ABIQ, $\beta = .59$, $p < .01$, but not at low levels of infant distress, $\beta = .07$, $p = .51$. More easily distressed infants exhibited lower cognitive skills at 36 months when mothers exhibited more intrusiveness and insensitivity during interactions and higher 36-month cognitive skills when 9-month interactions were less intrusive and more sensitive. The Distress X PCERA-3 (Frustration, Hostility) interaction was not a significant predictor of ABIQ.

Infant vagal tone and child outcomes

Higher basal vagal tone significantly predicted fewer externalizing problems at 36 months, $\beta = -.19$, $p < .05$, but it did not predict internalizing problems or cognitive skills. Interactions between infant basal vagal tone and PCERA factors did not predict 36-month behavior problems or cognitive skills, suggesting that basal vagal tone did not function as a susceptibility factor.

Discussion

Research focusing on DS suggests that temperamentally reactive infants who experience suboptimal caregiving are at risk for developing problematic social outcomes, whereas temperamentally reactive infants who experience positive caregiving are likely to experience enhanced outcomes (Mesman et al., 2009; Pluess & Belsky, 2009; Stright, Gallagher, & Kelley, 2008; Belsky et al., 1998). The present study found that prone-to-distress preterm infants were more susceptible to the effects of both positive and negative parenting in the development of externalizing but not internalizing problems at 36 months. These findings extend research focusing on DS to preterm infants, and also support findings examining 24-month behavior problems in preterm infants (Poehlmann et al., 2011).

When infants exhibit temperamental proneness to distress, they may be more sensitive or reactive to environmental variations; thus, parental expressions of negative affect, notably frustration or criticism,

during interactions may be particularly dysregulating for some preterm infants. Parenting did not relate to child behavior problems when infants were not prone to distress, suggesting that some preterm children may be less sensitive to parenting variations, consistent with the DS model (Belsky et al., 2007). Drawing on theory articulated by Belsky (2005), evolutionary processes may have resulted in variations in proneness to distress in infants such that parenting affects cognitive and social development differentially. Such variability may be a relic of natural selection that would have enhanced the survival of infants even under varying parenting environments. However, it is unlikely such a process would substantially affect reproductive fitness in current times.

Findings also extend our knowledge of DS to cognitive development in preterm infants. Easily distressed preterm infants exhibited more optimal cognition when maternal interactions included more positive affect and less intrusiveness and insensitivity. Conversely, these children exhibited less optimal cognitive skills when parenting was less positive. However, for preterm infants without proneness to distress, parenting was unrelated to cognitive skills. Our findings suggest that DS may not be limited to preterm children's social outcomes but extend to cognitive outcomes.

Unlike proneness to distress, infant basal vagal tone did not function as a susceptibility factor but directly predicted 36-month externalizing problems. This suggests the possibility of lasting effects of early physiological reactivity or dysregulation on later social development in preterm infants, confirming previous findings in preterms linking lower vagal tone with subsequent externalizing problems (Feldman, 2009).

Limitations

Although the sample was fairly representative of the U.S. population and attrition was low, families lost to attrition were slightly more socioeconomically disadvantaged than families continuing to participate. Moreover, the relatively small sample size may limit generalizability. The number of statistical tests performed was relatively high although it is the approach recommended by Belsky et al. (2007) for testing the DS model. Inclusion of a full-term group would help elucidate the extent to which DS in preterm children may differ from full-term children. An additional limitation is the number of prefeeding HRV recordings that were unusable because of infants becoming fussy. Future research could also incorporate parent reports of infant temperament as well as observational methods, although maternal-reported infant negative temperament and maternal depressive symptoms tend to be correlated (Beck, 1996). Although use of multiple LAB-TAB tasks is a strength, the behaviors or emotions elicited by unpredictable versus occluded toys may differ, with

more differentiated behaviors, emotions and meaning apparent as infants grow older. For preterm infants at 9 months, it is possible that elicited distress behaviors and their meanings are not dissimilar across tasks, although further research should explore such possibilities.

Conclusions

Our findings raise the possibility that temperamentally prone-to-distress preterm infants may benefit from closer developmental and behavioral surveillance and may be uniquely advantaged by interventions focused on enhancing parenting (Blair, 2002). Such proneness to distress, sometimes referred to as negative emotionality or irritability depending on the assessments used, can be observed during novel or frustrating conditions. Other studies have included clinically-based observation with neonates (e.g., irritability on the Neonatal Behavior Assessment Scale; Brazelton, 1973) to screen for infant negative emotionality prior to providing intervention. For example, in her intervention study focusing on maternal sensitive responsiveness with infants prone to irritability, van den Boom (1994) found that intervention mothers were significantly more responsive, stimulating, and visually attentive, and that intervention infants were more sociable and

self-soothing and cried less at 9 months compared with a no-intervention control group. This study highlights the types of interventions that may best benefit mothers of prone-to-distress infants. The contrasting effects of temperament on child outcomes in preterm infants who experience different parenting styles also demonstrate how the DS model can elucidate mechanisms that support the development of resilience in premature infants. Such differential effects should be examined in future intervention and resilience research, and may be particularly salient in designing follow-up programs to provide developmental and behavioral monitoring for preterm children.

Acknowledgements

This research was supported by grants from the National Institutes of Health (R01HD44163) and the University of Wisconsin (WARF) awarded to Dr. Poehlmann.

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What is known

Even in the absence of significant neurodevelopmental disability, preterm infants exhibit lower cognitive abilities and more behavior problems than full-term infants.

What is new

For temperamentally prone-to-distress preterm infants, more optimal parenting predicted higher cognitive skills and fewer externalizing behaviors at 36 months, whereas less optimal parenting predicted lower cognitive skills and more externalizing problems at 36 months.

What is clinically relevant

Temperamentally prone-to-distress preterm infants may benefit from closer developmental and behavioral surveillance and may be targeted for interventions that promote positive parenting.

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Accepted for publication 15 March 2012

Published online: 15 May 2012