Journal of the International Neuropsychological Society (2019), **25**, 362–374.

doi:10.1017/S1355617719000080

Resilience in Extremely Preterm/Extremely Low Birth Weight Kindergarten Children

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(RECEIVED July 9, 2018; FINAL REVISION November 20, 2018; ACCEPTED December 10, 2018)

Abstract

Objectives: Research on developmental outcomes of preterm birth has traditionally focused on adverse effects. This study investigated the prevalence and correlates of resilience in 146 extremely preterm/extremely low birth weight (EPT/ELBW) children (gestational age <28 weeks and/or birth weight <1000 g) attending kindergarten and 111 term-born normal birth weight (NBW) controls. **Methods:** Adaptive competence (i.e., "resilience" in the EPT/ELBW group) was defined by scores within grade expectations on achievement tests and the absence of clinically elevated parent ratings of child behavior problems. The "adaptive" children who met these criteria were compared to the "maladaptive" children who did not on child and family characteristics. Additional analyses were conducted to assess the conjoint effects of group (ELBW *vs*. NBW) and family factors on adaptive competence. **Results:** A substantial minority of the EPT/ELBW group (45%) were competent compared to a majority of NBW controls (73%), odds ratio (95% confidence interval) = 0.26 (0.15, 0.45), $p < .001$. Adaptive competence was associated with higher cognitive skills, more favorable ratings of behavior and learning not used to define adaptive competence, and more advantaged family environments in both groups, as well as with a lower rate of earlier neurodevelopmental impairment in the EPT/ELBW group. Higher socioeconomic status and more favorable proximal home environments were associated with competence independent of group, and group differences in competence persisted across the next two school years. **Conclusions:** The findings document resilience in kindergarten children with extreme prematurity and highlight the role of environmental factors as potential influences on outcome. (*JINS*, 2019, *25*, 362–374)

Keywords: Premature birth, Competence, Family, Environmental impact, Cognitive function, Development

INTRODUCTION

Research on childhood outcomes of extreme prematurity has focused primarily on the nature and predictors of developmental impairment. Findings indicate that extremely preterm/extremely low birth weight (EPT/ELBW) children (gestational age [GA] <28 weeks or birth weight <1000 g) score more poorly on measures of cognitive abilities and have more learning and behavior problems compared to term-born normal birth weight (NBW) controls (GA ≥37 weeks, birth weight >2500 g) (Johnson, Wolke, Hennessy, & Marlow, 2011). These deficits are evident in early childhood and persist over time (Baron, Erickson, Ahronovich, Baker, & Litman, 2011; Taylor, Minich, Klein, & Hack, 2004). Although adverse outcomes are also evident in very preterm/very low birth weight (VPT/VLBW) children (GA <32 weeks or birth weight <1500 g), impairments are more severe and pervasive for children with more extreme prematurity and neonatal complications such as bronchopulmonary dysplasia or brain abnormality on cranial ultrasonography (Aarnousde-Moens, Weisglas-Kuperus, Van Goudoever, & Oosterlaan, 2009; Aylward, 2005; Brydges et al., 2018). Greater social disadvantage is also associated with worse outcomes (Joseph, O'Shea, Allred, Heeren, & Kuban, 2017; Taylor et al., 2004).

However, outcomes of preterm birth vary substantially (Hopp & Baron, 2017), and the children who attain

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age-expected levels of achievement and behavioral adjustment are appropriately characterized as "resilient" (Luthar, Cicchetti, & Becker, 2000; Masten, 2001, 2014). Taylor, Klein, Minich, and Hack (2000) found that 37% of a cohort of <750 g birth weight children of middle school age were free of cognitive, learning, and behavioral deficits, compared to 82% of NBW controls. Gargus et al. (2009) observed that 24% of children with 901–1000 g birth weight scored in the average range on developmental testing and had normal neurological examinations at 18–22 months corrected age. In a population-based study using Florida public school records, 65% of children with GA 22–23 weeks were considered to be academically ready for kindergarten compared to 85% of full-term children (Garfield et al., 2017). However, these studies are among the few to focus on resilient EPT/ELBW children and did not examine positive outcomes in relation to multiple child and family characteristics.

In contrast to research on adverse outcomes, studies of resilience investigate factors that promote the development of adaptive competencies in high-risk children (Masten, 2001, 2014). High-risk groups are defined as those at social disadvantage or with biological vulnerabilities such as preterm birth. Adaptive competencies are conceptualized as age-appropriate functioning in developmentally salient domains, including academic achievement and social-behavioral adjustment. Potential promotive or protective factors are child traits or environmental characteristics that contribute to these competences, such as higher child cognitive and self-regulatory skills, greater socioeconomic advantage, and more supportive and stimulating home environments. A key difference between promotive-protective and vulnerability-risk factors is their potential to have different mechanisms of effect, the former viewed as growth promoting or compensatory and the latter as disruptive or maladaptive (Luthar et al., 2000; Rutter, 1987).

In the "person-centered" approach to the study of resilience, high-risk children with adaptive competencies are compared to high-risk children who lack adaptive competence to identify factors related to positive adaptation. Resilient children are also compared to competent low-risk peers to determine if the former children have weaknesses in some areas despite their adaptive competencies or, alternatively, if they have special strengths or resources that help offset their heightened risk for developmental problems (Masten et al., 1999). A second "variable-centered" approach examines the effects of both risk status (high *vs*. low) and protective factors on adaptive competence. In this approach, methods such as regression analysis are used to determine if protective factors such as favorable child or environmental characteristics offset risks and if high-risk children benefit more from these characteristics or are more vulnerable to their absence than those at low risk.

This study identified adaptive competencies in a sample of EPT/ELBW kindergarten children and NBW controls. Primary goals were to: (1) compare the EPT/ELBW and NBW groups on rates of adaptive competence; (2) use person-centered methods to compare the resilient, or "adaptive," subset of EPT/ELBW children to both EPT/ELBW children who failed to meet criteria for adaptive competence (i.e., the "maladaptive" subset) and to adaptive NBW controls on child and family characteristics; and (3) apply a variable-centered approach to investigate the conjoint effects of group and environmental factors on adaptive competence. To identify earlier medical and developmental correlates of resilience in the EPT/ELBW children, the adaptive and maladaptive subsets of this group were also compared on neonatal characteristics and rates of neurodevelopmental impairment earlier in childhood.

We hypothesized that some children in the EPT/ELBW group, although proportionally fewer than in the NBW group, would meet criteria for adaptive competence in kindergarten. Using the person-centered approach and based on past research on resilient children (Masten, 2014; Nelson et al., 2015), we further hypothesized that adaptive EPT/ELBW children, when compared with the maladaptive children in this group, would have higher cognitive abilities, more positive parent and teacher ratings of behavior and learning on assessments not used to define adaptive competence, and more advantaged family environments. We also examined the possibility that adaptive competence in the EPT/ELBW group would be associated with less extreme prematurity and lower rates of neonatal complications. In view of the vulnerability of EPT/ELBW children to cognitive weaknesses, we further anticipated that the adaptive subset of this group would obtain lower test scores than the adaptive subset of NBW controls. Demonstration of such differences would support the possibility that the adaptive EPT/ELBW children were able to compensate for cognitive weaknesses in attaining adaptive competence.

The variable-centered approach was applied to examine the combined effects of group (EPT/ELBW *vs*. NBW) and the family environment on adaptive competence in kindergarten. Findings from these analyses were expected to confirm independent associations of group and measures of the family environment with adaptive competence, with higher rates of competence for the NBW group than for the EPT/ELBW group and for children from more advantaged family environments. Associations of more positive family environments with adaptive competence were anticipated for both groups, but it was unclear if these associations would be stronger or weaker for preterm children compared to NBW controls. Some studies report that these associations are more pronounced for preterm than for NBW children (Greenley, Taylor, Drotar, & Minich, 2007; Gross, Mettelman, Dye, & Slagle, 2001; Jaekel, Pluess, Belsky, & Wolke, 2015; Landry, Smith, & Swank, 2006; Wolke, Jaekel, Hall, & Baumann, 2013), while others suggest weaker associations for preterm children (Joseph et al., 2017; Taylor, Klein, Drotar, Schluchter, & Hack, 2006; Treyvaud et al., 2012).

A final exploratory goal was to investigate the stability of adaptive competence across the first 3 school years. Longitudinal follow-up of the present sample and other preterm cohorts documents persisting deficits in academic achievement and behavior (Johnson et al., 2011; Taylor et al., 2018).

https://doi.org/10.1017/S1355617719000080 Published online by Cambridge University Press

Table 1. Sample characteristics

Characteristic	Group	
	EPT/ELBW ($n = 146$)	NBW ($n = 111$)
Neonatal and early developmental status:		
GA, mean in weeks (*SD*)	25.85 (1.65)	> 36
Birth weight in grams, mean (*SD*)*	816.67 (172.85)	3382.07 (446.21)
SGA,[a] *n* (%)	37 (25.5)	–
Multiple birth, *n* (%)*	31 (21.2)	0 (0)
Severely abnormal cranial ultrasound,[b] *n* (%)	15 (10.3)	–
Bronchopulmonary dysplasia,[c] *n* (%)	77 (53.1)	–
Infection or necrotizing enterocolitis, *n* (%)	59 (40.4)	–
Severe retinopathy of prematurity,[d] *n* (%)	27 (18.6)	–
Neurodevelopmental impairment,[e] *n* (%)	59 (41.3)	–
Neurosensory disorder, *n* (%)	16 (11.0)	–
BSID-2 MDI <70, *n* (%)	56 (39.2)	–
Child status in kindergarten:		
Age in years at testing, mean (*SD*)	5.96 (0.36)	5.96 (0.31)
Male sex, *n* (%)	67 (45.9)	51 (45.9)
African American, *n* (%)	90 (61.6)	61 (55.0)
Months in school at testing, mean (*SD*)*	4.24 (2.35)	6.38 (1.72)
Months in school at teacher rating, mean (*SD*)	7.16 (1.76)	7.11 (1.68)
Family status:		
zSES, mean (*SD*)	–0.05 (1.02)	0.06 (0.98)

BSID-2 MDI = Bayley Scales of Infant Development, 2nd Ed. (Bayley, 1993) Mental Development Index.
*$p < .05$.
[a]SGA defined by birth weight <2 *SD*s below expectation for GA based on data from Yudkin, Aboualfa, Eyre, Redman, and Wilkinson (1987). High rate due to inclusion of children with birth weight <1000 g but GA ≥28 weeks.
[b]Defined as clinician identified Grade III/IV intraventricular hemorrhage, periventricular leukomalacia, or ventricular dilatation at discharge.
[c]Defined as supplemental oxygen at 36 weeks corrected age.
[d]Defined as Stage 4 or 5 retinopathy or treatment with cryotherapy or laser therapy.
[e]Defined as neurosensory disorder (cerebral palsy or vision or hearing impairment) or BSID-2 MDI <70 at 20 months corrected age.

Research with community samples also suggests that children regarded as resilient earlier in childhood continue to do better academically and behaviorally over time than those with less adaptive competence at younger ages (Masten, 2014). We thus anticipated that the adaptive competence would remain relatively stable across the early school years.

METHOD

Sample

The sample included 146 of 148 EPT/ELBW children from a 2001–2003 birth cohort treated at a single hospital and recruited during their first year in kindergarten from a total population of 198 surviving infants without congenital malformations or infections (Taylor et al., 2018). There were no differences between the children recruited and non-participants in sex, race, or neonatal characteristics (Scott et al., 2012). The two children from the larger project not included in this study were missing data on the measures used to assess adaptive competence.

A group of 111 NBW controls was also recruited by individual matching of EPT/ELBW children who attended regular kindergarten classrooms with NBW peers from the same or similar classrooms on the basis of age, sex, and race. Matches were not recruited for the 15 EPT/ELBW children who were in full-time special education programs. Matches for another 22 children were not made due to home schooling of the EPT/ELBW child, schools that refused participation or were an excessive distance from the research center, or difficulties in finding appropriate matches.

Group characteristics are listed in Table 1. The groups did not differ in age at assessment, sex, race, or socioeconomic status (SES) as defined by the mean of sample z scores for maternal education, caregiver occupation, and census-based median income (socioeconomic status as defined by mean of sample Z-scores for maternal education, caregiver occupation, and census-based family income [zSES]; Orchinik et al., 2011). Because NBW controls were not recruited until after assessment of the EPT/ELBW children to whom they were matched, the NBW group was assessed significantly later on average in the school year. However, time in school overlapped considerably between the two groups as recruitment of EPT/ELBW children was staggered from October to May and NBW controls were enrolled as soon as could be arranged following assessment of EPT/ELBW children.

Of the children assessed in kindergarten (year 1), 241 (94%) were reassessed in year 2 and 229 (89%) in year 3.

https://doi.org/10.1017/S1355617719000080 Published online by Cambridge University Press

Comparisons of children who were assessed in all 3 years did not differ significantly from those who dropped out in group membership, sex, or zSES, although higher proportions of completers were white and met criteria for adaptive competence in kindergarten. EPT/ELBW children who remained in the study did not differ significantly from those who dropped out in the neonatal characteristics listed in Table 1.

Procedures

Children were assessed in half-day sessions by examiners not informed of their birth status while their parents completed interviews and ratings of child behavior and the home environment. With caregiver permission, teachers of the 109 EPT/ELBW children in regular kindergarten classrooms and 107 NBW controls completed ratings of child behavior and learning progress. The second and third assessments were conducted at approximately 1-year intervals after the initial visit. The project was IRB-approved and completed in accordance with the Helsinki Declaration.

Study measures are listed in Table 2. Achievement tests measured letter and word recognition, spelling to dictation, and mathematics concepts and problem solving. Cognitive tests included measures of IQ and composite scores for six skill domains: verbal comprehension, phonologic processing, spatial/nonverbal reasoning, motor/visual-motor ability, verbal memory, and executive function. Grouping of cognitive tests into these domains was based on test content and justified by internal reliabilities in the moderate-to-high range (Cronbach's alphas, .66-.83) and associations of the domain scores with academic achievement (Taylor et al., 2018).

Behavior assessments comprised parent and teacher ratings of problems in behavior and executive function and teacher ratings of behavior, social competence, and learning progress relative to curricular objectives for written language and mathematics (Taylor et al., 2011). The tests of children's abilities and behavior ratings have good reliability and validity, with previous findings documenting significantly lower test scores and higher behavior problem ratings in kindergarten for the EPT/ELBW group compared to NBW controls (Orchinik et al., 2011; Scott et al., 2012; Taylor et al., 2011).

Adaptive competence was defined as: (a) grade-based standard scores ≥85 on the Letter-Word Identification, Spelling, and Applied Problems tests of the Woodcock Johnson Tests of Achievement, 3rd Edition (Woodcock, McGrew, & Mather, 2001a); and (b) parent ratings below the borderline clinical range (<93rd percentile) on all DSM-Oriented scales of the Child Behavior Checklist (CBCL, Achenbach & Rescorla, 2001). Kindergarten children who met these criteria were classified as "adaptive" and those who did not as "maladaptive," with these same criteria applied in classifying adaptive competence in years 2 and 3. Past research documents the validity of low achievement scores in identifying children with learning problems (Litt, Taylor, Klein, & Hack, 2005), as well as the reliability of the DSM-Oriented scales and the validity of a cut-off at the 93rd percentile in discriminating children with and without corresponding DSM diagnoses (Ebesutani et al., 2010; Nakamura, Ebesutani, Bernstein, & Chorpita, 2009).

The rationale for classifying adaptive competence in this manner was to provide a broad and relatively strict screen for problems likely to exclude children with significant learning or behavior problems. The majority of children classified as maladaptive (57%) failed to meet criteria for competence on ≥2 measures. Impairments were most often identified on Applied Problems (56% of children classified as maladaptive) and Spelling (52%), and less often identified on Letter-Word Identification (17%) and the CBCL DSM-Oriented scales ADHD Problems (26%), Conduct Problems (22%), Anxiety Problems (16%), Somatic Problems (16%), Oppositional Defiant Problems (15%), and Affective Problems (13%).

The family environment was evaluated using distal and proximal assessments of social advantage. Past reports document associations of higher distal social advantage, as measured by zSES, with higher test scores and fewer behavior problems (Orchinik et al.., 2011; Scott et al., 2012; Taylor et al., 2011, 2018). Multi-component measures of SES have been used in previous research (Burchinal, Roberts, Zeisel, Hennon, & Hooper, 2006; Clark & Woodward, 2015; Farah, 2017) and were justified in this study by independent associations of the three components of zSES with one or more measures of kindergarten outcome in the NBW group (data not shown).

Proximal measures of the family environment were selected to assess a broad range of family influences and because of their associations with academic achievement, behavior, illness severity, and other family characteristics (Gerard, 1994; Griffin & Morrison, 1997; Hargrove & O'Dell, 1999; Lai, O'Mahony, & Mulligan, 2015; Williams, Piamjariyakul, Williams, Bruggeman, & Cabanela, 2006). All measures were completed using parent questionnaires or interviews. The Home Observation for Measurement of the Environment (HOME; Bradley, Caldwell, Rock, Hamrick, & Harris, 1988) was administered in an interview format similar to that used in previous studies validating this method (Jacobson & Jacobson, 1996; Lai et al., 2015; Linares et al., 2006). A principal axis factor analysis conducted to reduce the measures to a smaller set of family constructs yielded a 3-factor solution (see Table 3). Factor scores were defined as the mean of the sample *Z*-scores for measures with single factor loadings ≥ .4 and without cross-loadings ≥ .3, with higher scores reflecting: (1) higher stimulation for learning, (2) higher parent-child relationship quality, and (3) lower parent burden and distress. Similar factors are described in previous research on family influences (Masten et al., 1988; Nelson et al., 2015).

Data Analysis

Analyses used general estimating equations (GEE; Diggle, Liang, & Zeger, 1994) to examine rates of adaptive

https://doi.org/10.1017/S1355617719000080 Published online by Cambridge University Press

Table 2. Assessments of child outcomes and the family environment

Domain	Measure	Reference	Score
Academic achievement:	WJ-III-ACH Letter-Word Identification, Spelling, and Applied Problems	Woodcock, McGrew, & Mather (2001b)	Grade-based standard score
Cognitive tests:	*IQ:* WJ-III-COG Brief Intelligence Assessment (BIA)	Woodcock, McGrew, & Mather (2001a)	Grade-based standard score
	Verbal comprehension: WJ-III-COG Verbal Comprehension	Woodcock et al. (2001a)	Age-based standard score
	Phonological processing: CTOPP Elision and Blending Words	Wagner, Torgesen, & Rashotte (1999)	Mean of *Z* score transformations of age-based standard scores
	Spatial/nonverbal reasoning: WJ-III-COG Concept Formation and Spatial Relations	Woodcock et al. (2001a)	mean of *Z* score transformations of age-based standard scores
	Motor/visual-motor ability: WJ-III-COG Visual Matching; VMI; BOT-2 short form	Beery & Beery (2004); Bruininks & Bruininks (2005)	Mean of *Z* score transformations of age-based standard scores
	Verbal memory: modified Verbal Paired Associate Test immediate and delayed recall; CTOPP Memory for Digits	Gonzalez, Anderson, Wood, Mitchell, & Harvey (2007); Wagner et al. (1999)	Mean of age-based z scores for immediate and delayed recall[a] and *Z* score transformation of age-based standard score for Memory for Digits
	Executive function: Shape School; Preschool Trials-Revised; Test of Inhibition and Attention; Nebraska Barnyard	Orchinik et al. (2011)	mean of age-based z scores for the five tasks [a]
Child behavior ratings:	CBCL	Achenbach & Rescorla (2001)	T scores for DSM-Oriented scales [b,c]
	TRF	Achenbach & Rescorla (2001)	T scores for DSM-Oriented scales[b,c]
	BRIEF, parent and teacher versions	Gioia, Isquith, Guy, & Kenworthy (2000)	age-based T score for GEC[b]
	SSBS-2	Merrel (2003)	T scores for Social Competence and Antisocial Behavior[b,d]
	Teacher ratings of learning progress	Taylor et al. (2011)	Sum ratings for written language and mathematics
Family environment:	zSES	Orchinik et al. (2011)	mean of sample *Z* scores for maternal education, caregiver occupation, and census-based median income
	HOME interview format	Bradley, Caldwell, Rock, Hamrick, & Harris, 1988; Lai, O'Mahony, & Mulligan (2015)	sample *Z* scores of each of 8 subscales[e]
	Home Literacy Environment Scale	Griffin & Morrison (1997)	sample *Z* score for rating sum
	Parent Child Relationship Inventory (PCRI)	Gerard (1994)	sample *Z* scores of subscale ratings[f]
	Impact on Family Scale-revised	Stein & Jessop (2003)	sample z score for sum of ratings of negative impact of child health[b]
	Family Assessment Device, General Functioning scale (FAD-GF)	Miller, Bishop, Epstein, & Keitner (1985)	sample *Z* score for mean rating[b]
	Brief Symptom Inventory, Depression scale (BSI)	Derogatis & Melisaratos (1983)	sample *Z* score for rating[b]
	Life Stressors and Social Resources Inventory-Adult (LISRES-A)	Moos & Moos (1994)	sample *Z* scores of ratings for Parent Interpersonal Stressors and Resources[b,g]

WJ-III-ACH = Woodcock Johnson III Tests of Achievement; WJ-III-COG = Woodcock Johnson Tests of Cognitive Abilities; CTOPP = Comprehensive Test of Phonological Processing; VMI = Developmental Test of Visual Motor Integration; BOT-2 = Bruininks-Oseretsky Test of Motor Proficiency, 2nd Ed.
[a]Z scores represent deviations in *Z* score units of obtained scores from expected scores, with expected scores based on regression equation relating age and sex to scores for NBW controls.
[b]Higher scores reflect more problematic behaviors, family dysfunction, or parent stress; for all other measures higher scores reflect higher levels of child competence or more positive family characteristics.
[c]DSM-Oriented scales are Affective Problems, Anxiety Problems, Somatic Problems, ADHD Problems, Oppositional Defiant Problems, and Conduct Problems.
[d]Social Competence subscales: Peer Relations, Self-Management/Compliance, and Academic Behavior; Antisocial Behavior subscales: Hostile, Antisocial/Aggressive, and Defiant/Disruptive.
[e]Subscales are Responsivity, Encouragement of Maturity, Emotional Climate, Learning Materials, Enrichment, Family Companionship, Family Integration, and Physical Environment.
[f]Subcales: Parental Support, Satisfaction with Parenting, Involvement, Communication, Limit Setting, Autonomy, and Role Orientation.
[g]Parent Interpersonal Stressors subscales: Health, Work, Spouse, Extended Family, and Friends; Resources subcales: Work, Spouse, Extended Family, and Friends.

competence in the two groups and child/family correlates. The primary factors in the latter analyses were group, adaptive competence (adaptive *vs*. maladaptive), and the group x adaptive competence interaction. Family membership was included as a cluster variable in this and other analyses to account for sibling correlations. Time in school was not significantly associated with adaptive competence and, thus, not considered in the analyses. GEE was also used to conduct pre-planned contrasts of the adaptive EPT/ELBW children to the maladaptive subset of this group and to adaptive NBW controls on the child and family measures.

Variable-centered analyses used GEE to examine the conjoint effects of group and each of the family variables on adaptive competence, with the group × family factor

https://doi.org/10.1017/S1355617719000080 Published online by Cambridge University Press

Table 3. Pattern matrix from factor analysis of measures of the family environment

Measure[a]	Factor 1	Factor 2	Factor 3
HOME Enrichment	0.817	0.114	–0.060
HOME Learning Materials	0.725	–0.024	0.013
Home Literacy Environment Scale	0.618	0.125	–0.188
HOME Responsivity	0.537	–0.120	0.099
HOME Family Companionship	0.504	–0.032	0.026
HOME Physical Environment	0.418	–0.128	–0.102
PCRI Involvement	0.020	–0.829	0.006
PCRI Communication	0.056	–0.713	0.012
FAD GF	–0.020	0.508	0.274
PCRI Parental Support	–0.079	–0.179	–0.841
BSI Depression	–0.038	–0.046	0.717
LISRES-A Interpersonal Stressors	–0.111	0.011	0.426

Note. The three-factor solution was obtained using principal axis factor analysis with oblimin rotation and explained 59% of the variance in the measures. Factors were interpreted as measures of: (1) home environment for learning, (2) parent-child relationship quality, and (3) parent burden/distress. The factors were computed by averaging the sample z scores for each of the measures that loaded $\geq .4$ on a single factor, with higher scores on each factor computed to reflect more positive environments. Factor inter-correlations ranged from .37 to .42 (all $ps \leq .001$).
PCRI = Parent-Child Relationship Inventory; FAD GF = Family Assessment Device General Functioning scale; BSI = Brief Symptom Inventory; LISRES-A = Life Events and Social Resources Scale, Adult version.
[a]To ensure that scores were on a common metric for analysis, raw scores for each measure were converted to sample *Z* scores.

interaction included to explore group differences in family effects. Analyses first examined the family factors in separate models and then tested models that included combinations of those factors. The stability of adaptive competence in the two groups across years was examined using mixed model analysis. Predictors in these analyses were group, year, and the group × year interaction. Missing data were minimal.

Significance was defined as $p < .05$ without adjustment for multiple comparisons given the lack of preliminary information on the correlates of adaptive competence in EPT/ELBW children and an interest in using all available data. However, estimates of the magnitude of effects included 95% confidence intervals [CIs] and effect sizes (Cohen's d) for group differences and odds ratios (ORs) and CIs for predictors of adaptive competence. The lower boundaries for small, medium, and large effect sizes for group differences were .2, .5, and .8, respectively (Cohen, 1992).

RESULTS

Group Differences in Rates of Adaptive Competence

Group comparisons revealed that fewer EPT/ELBW children (65; 45%) compared to NBW controls (81; 73%) met criteria for adaptive competence, OR [CI] = 0.26 [0.15, 0.45], $p < .001$.

Correlates of Adaptive Competence

Table 4 summarizes results of person-centered comparisons of adaptive EPT/ELBW children to maladaptive EPT/ELBW children and adaptive NBW controls on child and family characteristics (see Supplementary Table 1 for descriptive data on these characteristics for all four subsets of children). Compared to maladaptive EPT/ELBW children, the adaptive subset of this group obtained: (a) higher scores on all cognitive and achievement tests; (b) lower ratings on the CBCL DSM-Oriented scales used to classify adaptive competence and on the Teacher's Report Form (TRF, Achenbach & Rescorla, 2001) DSM-Oriented scales for Affective, ADHD, and Conduct problems and the parent and teacher versions of the Behavior Rating Inventory of Executive Function-General Executive Composite (BRIEF-GEC, Gioia, Isquith, Guy, & Kenworthy, 2000); and (c) higher teacher ratings of social competence on the School Social Behavior Scale, 2nd Ed. (SSBS-2, Merrel, 2003) and teacher ratings of learning progress in written language.

The adaptive EPT/ELBW children also had higher zSES, higher home stimulation for learning, higher parent-child relationship quality, and lower parent burden and distress. Effect sizes were large for all cognitive measures, moderate-to-large for the BRIEF and most teacher ratings, and moderate for family measures. Adaptive competence was not significantly related to the neonatal characteristics listed in Table 1 but was associated with lower rates of early childhood neurodevelopmental impairment, OR [CI] = 0.19 [0.06, 0.64], $p = .008$. Despite this association, 12 (20%) of those with early impairment met criteria for adaptive competence in kindergarten.

The adaptive subsets of the two groups did not differ significantly on the achievement tests and behavior ratings used to classify adaptive competence or on measures of the family environment. However, compared to adaptive NBW controls, adaptive EPT/ELBW children had significantly lower cognitive test scores, higher teacher ratings on the BRIEF-GEC and TRF DSM-Oriented Anxiety and ADHD problems scales, and lower teacher ratings of social competence on the SSBS-2 and learning progress in written language and mathematics. Effect sizes for these measures were small-to-moderate. In additional exploratory comparisons (data not shown), differences between adaptive *versus* maladaptive NBW children were similar to those found in comparing these two subsets of the EPT/ELBW group.

Conjoint Effects of Group and the Family Environment in Predicting Adaptive Competence

Variable-centered analyses revealed that adaptive competence was associated with higher zSES, OR [CI] = 2.10 [1.43, 3.10], higher home stimulation for learning, OR [CI] = 2.03 [1.49, 2.77], higher parent-child relationship quality, OR [CI] = 1.54 [1.17, 2.03], and lower parent burden/distress, OR [CI] = 1.77 [1.35, 2.32], all $ps < .003$. Analyses failed to document interactions of group with any of the latter

https://doi.org/10.1017/S1355617719000080 Published online by Cambridge University Press

Table 4. Comparisons of adaptive and maladaptive subsets of EPT/ELBW children and NBW controls on measures of child and family characteristics

Subgroup comparison: Domain/measure	Adaptive vs. Maladaptive EPT/ELBW				Adaptive EPT/ELBW vs. Adaptive NBW			
	Mdif (*SE*)	CI	*p*	EF	Mdif (*SE*)	CI	*p*	EF
Academic achievement tests								
WJ-III-ACH Letter-Word Identification	12.33 (2.52)	7.38, 17.27	< .001	.84	−1.73 (2.20)	−6.04, 2.58	.432	.14
WJ-III-ACH Spelling	20.26 (2.72)	14.93, 25.60	< .001	1.22	−2.69 (2.03)	−6.66, 1.29	.185	.23
WJ-III-ACH Applied Problems	25.01 (2.67)	19.77, 30.25	< .001	1.52	−4.32 (2.27)	−8.76, 0.13	.057	.31
Cognitive skills:								
WJ-III-COG BIA	23.70 (2.92)	17.98, 29.43	< .001	1.36	−9.95 (2.39)	−14.64, −5.26	< .001	.70
Verbal comprehension	20.79 (2.96)	14.99, 26.60	< .001	1.17	−6.58 (2.69)	−11.84, −1.31	.014	.41
Phonological processing	0.80 (0.15)	0.51, 1.09	< .001	.92	−0.44 (0.14)	−0.71, −0.17	.001	.52
Spatial/nonverbal reasoning	1.11 (0.16)	0.79, 1.42	< .001	1.18	−0.40 (0.14)	−0.67, −0.14	.003	.48
Motor/visual motor skills	1.57 (0.23)	1.12, 2.03	< .001	1.18	−0.74 (0.18)	−1.10, −0.39	< .001	.72
Verbal memory	1.12 (0.18)	0.76, 1.49	< .001	1.05	−0.38 (0.15)	−0.68, −0.08	.012	.43
Executive function	1.62 (0.21)	1.21, 2.03	< .001	1.34	−0.55 (0.15)	−0.85, −0.25	< .001	.62
Parent/teacher ratings of behavior and learning:								
CBCL Affective Problems	−3.37 (0.83)	−5.00, −1.74	< .001	.63	0.63 (0.40)	−0.16, 1.41	.116	.27
CBCL Anxiety Problems	−2.82 (0.91)	−4.61, −1.03	.002	.49	0.40 (0.53)	−0.63, 1.44	.445	.13
CBCL Somatic Problems	−2.87 (0.86)	−4.56, −1.18	.001	.54	0.58 (0.54)	−0.47, 1.63	.280	.19
CBCL ADHD Problems	−6.02 (0.99)	−7.95, −4.09	< .001	.97	0.45 (0.52)	−0.56, 1.46	.380	.15
CBCL Oppositional Defiant Problems	−4.03 (0.87)	−5.75, −2.32	< .001	.72	0.09 (0.42)	−0.73, 0.91	.825	.04
CBCL Conduct Problems	−5.20 (0.96)	−7.09, −3.31	< .001	.85	−0.04 (0.44)	−0.91, 0.82	.919	.02
TRF Affective Problems	−3.63 (0.98)	−5.55, −1.71	< .001	.73	0.61 (0.70)	−0.76, 1.97	.382	.16
TRF Anxiety Problems	0.77 (1.21)	−1.59, 3.14	.522	.13	2.24 (1.06)	0.16, 4.33	.035	.43
TRF Somatic Problems	0.08 (0.65)	−1.19, 1.36	.900	.02	0.07 (0.63)	−1.17, 1.32	.909	.02
TRF ADHD Problems	−3.86 (1.30)	−6.40, −1.32	.003	.57	2.06 (1.02)	0.06, 4.06	.043	.40
TRF Oppositional Defiant Problems	−0.51 (1.24)	−2.94, 1.92	.681	.08	1.14 (1.01)	−0.84, 3.12	.260	.21
TRF Conduct Problems	−3.07 (1.13)	−5.30, −0.85	.007	.52	−0.14 (0.76)	−1.64, 1.35	.850	.03
BRIEF GEC parent version	−9.22 (1.80)	−12.75, −5.70	< .001	.82	−0.31 (1.53)	−3.31, 2.70	.841	.03
BRIEF GEC teacher version	−8.10 (2.42)	−12.84, −3.37	.001	.66	6.92 (2.03)	2.94, 10.89	.001	.68
SSBS-2 Social Competence	6.24 (1.60)	3.10, 9.39	< .001	.76	−5.66 (1.39)	−8.38, −2.93	< .001	.77
SSBS-2 Antisocial Behavior	−2.18 (1.52)	−5.15, 0.79	.150	.28	1.23 (1.15)	−1.02, 3.48	.284	.20
Teacher rating of learning progress, written language	−1.99 (0.37)	−2.71, −1.26	< .001	1.08	0.64 (0.28)	0.09, 1.19	.024	.46
Teacher rating of learning progress, mathematics	−0.55 (0.33)	−1.19, 0.09	.092	.38	0.44 (0.19)	0.07, 0.81	.021	.52
Family environment:								
zSES	0.78 (0.19)	0.41, 1.15	< .001	.74	0.19 (0.20)	−0.19, 0.58	.331	.17
Home stimulation for learning	0.61 (0.15)	0.32, 0.89	< .001	.63	−0.11 (0.15)	−0.39, 0.18	.452	.13
Parent-child relationship quality	0.49 (0.16)	0.18, 0.79	.002	.51	0.20 (0.16)	−0.12, 0.51	.218	.21
Parent burden/distress	0.44 (0.15)	0.16, 0.73	.002	.46	0.11 (0.13)	−0.16, 0.37	.426	.13

Note. Measurement units listed in Table 1. Home stimulation for learning, parent-child relationship quality, and parent burden/distress are means of the sample *Z* scores for the family measures with loadings ≥ .4 on factors 1-3, respectively (see Table 3). Due to non-normal distributions, scores on the CBCL and TRF were also analyzed using nonparametric Kruskal-Wallis test, with results similar to those reported above.
Mdif (*SE*) = mean difference (standard error); EF = effect size (Cohen's *d*); WJ-III-ACH = Woodcock Johnson Tests of Achievement, 3rd Ed.; WJ-III-COG = Woodcock Johnson Tests of Cognitive Ability, 3rd Ed.

factors. Associations of each of the proximal family factors with adaptive competence were independent of group and zSES, all *p*s < .05.

Adaptive Competence Across School Years 1–3

Group comparisons of adaptive competence across school years indicated a group main effect, $F(1,236) = 30.94$, $p < .001$, $d = .62$. Effects for year and group × year were not significant. Rates of adaptive competence in the EPT/ELBW *versus* NBW groups, respectively, were 47% *versus* 78% in year 2 and 55% *versus* 77% in year 3. Although some children changed classifications over time, 49 (82%) of the adaptive subset of EPT/ELBW kindergarten children continued to meet criteria for adaptive competence in year 2 and 53 (90%) in year 3. Similarly, 70 (89%) of the adaptive subset of NBW kindergarten children continued to meet these criteria in year 2 and 69 (90%) in year 3.

https://doi.org/10.1017/S1355617719000080 Published online by Cambridge University Press

DISCUSSION

Adaptive Competence in EPT/ELBW Children

The substantial minority (45%) of the EPT/ELBW group without impairments on achievement testing or on parent ratings of behavior confirms other findings suggesting age-appropriate functional outcomes, or “resilience,” in some EPT/ELBW children (Garfield et al., 2017; Hopp & Baron, 2017; Taylor et al., 2000). Adaptive competence in the EPT/ELBW group was associated with higher scores on tests of global and specific cognitive abilities, more advantaged family environments, and the absence of neurodevelopmental impairment earlier in childhood.

Associations of adaptive competence in EPT/ELBW children with higher cognitive abilities and more advantaged family environments mirror findings from research on resilience in children at high social risk (Burchinal et al., 2006; Jaffe, 2007; Masten, 2014). The findings are also consistent with past research on resilience in preterm children. Gargus et al. (2009) observed that ELBW children who were “unimpaired” in early childhood were at greater social advantage than those with impairments. Poehlmann-Tynan et al. (2015) followed a lower risk sample of preterm/low birth weight children (GA <37 weeks or <2500 g) from the neonatal period to early school age. Latent profile analysis was conducted on parent ratings of the children at 6 years of age to identify different profiles of outcome on measures of learning, behavior, social competence, and sleep. Findings suggested a latent class of “resilient” children, comprising 31% of the sample, with age-appropriate ratings on all measures. As younger children, the resilient subset had been exposed to less negative parenting and performed better on a delayed gratification task than children with more problematic parent ratings.

Other studies of preterm EPT/ELBW children identified positive outcomes in individual cases or subsets of their samples or examined associations of preterm birth with continuous measures of academic or behavioral competence (Bradley et al., 1994; Garfield et al., 2017; Hopp & Baron, 2017; Jaekel et al., 2015; Taylor et al., 2000; Treyvaud et al., 2012; Wolke et al., 2013). However, the latter studies either did not include NBW controls or failed to investigate child and family characteristics that distinguished preterm children who were functionally competent from those who were not.

Despite evidence for resilience in many EPT/ELBW children, the lower rate of adaptive competence in this group relative to NBW controls replicates a substantial body of research demonstrating adverse effects of extreme prematurity on achievement and behavior (Johnson et al., 2011; Scott et al., 2012; Taylor et al., 2011). Associations of lower cognitive abilities and less advantaged family environments with impairments in achievement and behavior are also in keeping with previous literature (Taylor et al., 2018). The findings add to knowledge on outcomes of extreme prematurity by documenting the potential for some EPT/ELBW children to attain normative levels of adaptive functioning and by revealing factors associated with these positive outcomes.

Although positive and negative outcomes of high-risk conditions are often opposite sides of the same continuum, positive outcomes cannot be attributed merely to the absence of adversity but also to protective-promotive factors that facilitate age-typical performance in functionally salient aspects of development (Luthar et al., 2000; Masten, 2011; Rutter, 1987). Identification of factors associated with adaptive competence suggests targets for intervention to optimize development in all at-risk children rather than merely treat negative outcomes.

Adaptive Competence in EPT/ELBW Children Versus NBW Controls

Adaptive EPT/ELBW children were similar in many respects to adaptive NBW controls. These subgroups did not differ significantly on the achievement tests or parent ratings used to classify adaptive competence, several other parent and teacher ratings of behavior, or measures of the family environment. These findings are consistent with research on children at high social risk (Masten et al., 1999) and document competencies in the adaptive EPT/ELBW children that extended beyond those used to classify adaptive competence.

Other findings suggested limitations to these positive outcomes. Compared to adaptive NBW controls, adaptive EPT/ELBW children obtained lower scores on cognitive testing, higher teacher ratings of executive dysfunction, anxiety, and ADHD, and lower teacher ratings of social competence and learning progress. Parents may have been less aware of behavior and learning difficulties evident at school and adaptive competence thus less robust for the adaptive EPT/ELBW children. As adaptive EPT/ELBW children were selected on the basis of scores that departed further from group means than was the case for adaptive NBW children, scores on other measures would be more likely to distinguish the two groups as a result of regression to the mean. Nevertheless, many EPT/ELBW children demonstrated age-appropriate achievement and were not rated by their parents as having clinically significant behavior problems.

Factors Associated With Adaptive Competence

Results of variable-centered analyses confirming independent associations of adaptive competence with preterm birth and the family environment accord with past research on the effects of these factors on children’s cognitive, achievement, and behavioral outcomes (Clark, Woodward, Horwood, & Moor, 2008; Jaekel et al., 2015; Johnson, 2007; Orchinik et al., 2011; Taylor, Klein, Schatschneider, & Hack, 1998; Taylor et al., 2000; Vanderbilt-Adriance & Shaw, 2008). Independent effects of distal and proximal measures of the family environment on development also parallel results of previous studies of children at social risk and preterm cohorts (Nelson et al., 2015; Treyvaud et al., 2012; Wolke et al., 2013).

Measures of the family environment were moderately intercorrelated and past research suggests that proximal family factors may partially mediate the effects of distal social risk on children's development (Burchinal et al., 2006; Treyvaud et al., 2012). Although more complex models of environmental effects were not examined in this study, associations of zSES with adaptive competence that were independent of the effects of proximal family factors raises the possibility that zSES reflected a wider set of influences on learning and behavior, such as family instability, negative life events, the quality of children's schooling, neighborhood poverty, and access to health and community resources (Andreias et al., 2010; Bradley & Corwyn, 2002; Masten & Coatsworth, 1998; Masten et al., 1999).

Results failed to reveal significant group differences in associations between adaptive competence and the family environment. Consistent with these findings, Clark and Woodward (2015) did not find differences between preterm and NBW children in associations of early childhood measures of parenting with later performance on tests of executive function. Treyvaud et al. (2012) also failed to find moderating effects of birth status (preterm *vs*. NBW) on associations of the home environment with most measures of early childhood behavior. The one exception to these findings was their report of an association of a higher quality home environment with better behavioral self-regulation for NBW children that was not evident for preterm children with white matter abnormalities on neuroimaging. While the latter finding is consistent with research suggesting that preterm birth may constrain children's opportunity to take advantage of environmental supports (Joseph et al., 2017; Taylor et al., 2004, 2006), other studies provide evidence either for protective effects of positive environments on preterm children (Gross et al., 2001; Taylor et al., 1998) or for a special vulnerability of these children to disadvantaged family environments (Jaekel et al., 2015; Treyvaud et al., 2012). The extent to which environmental factors have different associations with outcomes in preterm compared to NBW children may depend on the characteristics of the preterm children under investigation and the nature of the outcome measure (Masten et al., 1988; Taylor et al., 2004).

Persistence of Adaptive Competence

Adaptive competence was evident in EPT/ELBW children during their first year in school and rates of adaptive competence remained at similar levels across the next 2 school years. The results suggest that adaptive competence in both groups was already established by school entry without marked changes across years, despite grade-related increases in learning demands. Previous longitudinal research on resilience in children at high social risk also suggests stability of adaptive competence with advancing age, while acknowledging that changes in competency can vary as children face new developmental challenges or opportunities (Luthar et al., 2000; Masten, 2011; Masten & Coatsworth, 1998; Rutter, 2013).

Potential Mechanisms

Several possible explanations can be offered for the capacity of many EPT/ELBW children to meet broad expectations for age on achievement tests and parent behavior ratings. One possibility is that their relatively advantaged family environments provided them with additional opportunities to learn and facilitated more engagement in learning readiness tasks and more positive behavioral adaptations (Bradley et al., 1994; Clark & Woodward, 2015; Masten, 2014; Treyvaud et al., 2012). In light of research linking environmental advantage and early parent training to increased brain growth in young children, their more positive family environments may also have facilitated either more normal early brain development or a greater degree of neural reorganization or compensation (Farah, 2017; Hair, Hanson, Wolfe, & Pollak, 2015; Milgrom et al., 2010; Noble et al., 2015; Ursachec & Noble, 2016).

A second possibility is that the adaptive subset of EPT/ELBW children sustained less severe perinatal brain abnormalities than those in the maladaptive subset. While differences in the degree abnormality in neonatal brain development may have contributed to the different outcomes of the two subsets of EPT/ELBW children, the more positive outcomes of the adaptive subset is unlikely to reflect a total absence of neural abnormality at birth (Inder, Wells, Mogridge, Spencer, & Volpe, 2003; Woodward, Anderson, Austin, Howard, & Inder, 2006). Barnett et al. (2018) document multiple types of brain abnormalities in preterm children and provide evidence for their combined effect on outcome. The case for absent or limited initial neurological involvement as the sole determinant of resilience is further weakened by the lack of association of neonatal risk factors with adaptive competence and the fact that 20% of the adaptive EPT/ELBW children had early childhood neurodevelopmental impairment.

Other possibilities are that some children were genetically less susceptible to early brain insult, had higher innate potential, neural "reserve," or capacity for neural compensation than others (Luu, Vohr, Allan, Schneider, & Ment, 2011; Stern, 2009; Stiles, Reilly, Paul, & Moses, 2005), or that gene-environment correlations contributed to both parenting characteristics and children's developmental outcomes (Cicchetti, 2013; Rutter & Silberg, 2002). Mechanisms underlying resilience may also involve multiple influences on development, as when positive parenting fosters higher levels of executive function, which in turn facilitates children's academic growth and behavioral adjustment (Masten, 2011).

The higher cognitive skills of the adaptive subset of EPT/ELBW children relative to the maladaptive subset likely

https://doi.org/10.1017/S1355617719000080 Published online by Cambridge University Press

contributed to their adaptive competence. Any explanations of resilience in EPT/ELBW children will thus need to account for this more generalized pattern of sparing and not for adaptive competence alone. A viable account of resilience will also need to explain how the adaptive subset of EPT/ELBW children were capable of broadly age-typical achievement and parent ratings of behavioral adjustment, despite having both lower cognitive skills and teacher ratings of more learning and behavior problems relative to adaptive NBW controls.

The limited set of academic skills assessed by the tests and the greater demands on children's learning and behavior at school may help to account for these disparities. Alternatively, environmental enrichment and its effects on neural systems underlying learning and behavior may have helped the adaptive EPT/ELBW children compensate for their weaknesses (Bryck & Fisher, 2012; Jaffe, 2007; Jolles & Crone, 2012; Luu et al., 2011; Ursache & Noble, 2016).

Study Limitations

A limitation of this study is that adaptive competence was defined using pre-selected standard score cutoffs on achievement tests and parent ratings of child behavior. Although results likely would have differed had competence been defined using other criteria, the cutoffs used were based on scores that fell within grade or age expectations on standardized measures and considered functioning across a range of academic skills and behaviors. Differences between the adaptive and maladaptive subsets of both groups on measures of functioning not used to define competence also support the validity of our criteria.

Another measurement limitation is that the study did not consider a wider range of factors potentially related to adaptive competence, such as children's motivational status and self-efficacy, their history of engagement in special education and developmental programs, and community resources (Bradley & Corwyn, 2002; Luthar et al., 2000; Rutter, 2013). Additionally, teacher ratings were obtained only for children attending regular classrooms. As many of the EPT/ELBW children without teacher ratings were in full-time special education placements for learning or behavior problems, differences between adaptive and maladaptive children on these measures would likely have been greater had teacher ratings also been obtained for these children.

Finally, analyses did not correct for multiple comparisons and the sample was recruited from a 2001–2003 birth cohort from a single site. Further replications are needed to examine correlates of resilience, and caution is advised in generalizing findings to the broader population of more recent EPT/ELBW cohorts.

Despite these limitations, the study included a sample of kindergarten EPT/ELBW children and NBW controls from the same or similar classrooms, extensive assessments provided an opportunity to investigate multiple factors associated with adaptive competence, and rates of developmental morbidities in extremely preterm children remain high, despite recent improvements in survival (Rogers & Hintz, 2016).

Implications and Future Directions

Documentation of adaptive competence in a substantial minority of kindergarten EPT/ELBW children reinforces their potential for resilience and suggests that resilience is evident by the age of school entry. The results indicate that adaptive competence is related to higher cognitive abilities; fewer problems in self-regulatory behaviors as measured by the BRIEF; higher social, behavioral, and academic functioning at school; and more advantaged family environments. These findings confirm the potential benefits of early childhood interventions to enhance learning and behavioral outcomes in high-risk children (Clark & Woodward, 2015; Masten, 2011; Nelson et al., 2015).

Associations of adaptive competence with each of the three proximal family factors also support the possibility of promoting better outcomes for at-risk children through interventions that provide learning opportunities for the child, encourage positive parent-child engagement and communication and more supportive and less conflictual family relationships, and reduce parent distress (Bradley et al., 1994; Burchinal et al., 2006). The weaknesses that EPT/ELBW children have in cognition and psychosocial functioning may need to be considered in designing family interventions (Taylor, Klein, & Hack, 2001), but the current findings suggest that these interventions are as applicable to preterm children as to their NBW peers.

Further research is needed to examine different forms of resilience EPT/ELBW children (academic achievement, social-emotional adjustment, daily living skills) and enhance understanding of the "adaptive systems" that help them attain developmentally appropriate levels of competence despite risks for more adverse outcomes (Masten, 2001). Study of neural and genetic differences between adaptive and maladaptive EPT/ELBW children may provide additional insights into mechanisms underlying resilience (Farah, 2017; Masten, 2011; Treyvaud et al., 2012). As a process that evolves with age and is subject to new challenges, it will also be important to examine resilience longitudinally in relation to changing experiences and to identify precursors of school-age outcomes and ways to foster early development (Luthar et al., 2000; Masten, 2011; Poehlmann-Tynan et al., 2015).

ACKNOWLEDGMENTS

Funded by grant HD050309 from the National Institutes of Health. We acknowledge the assistance of Anne Birnbaum, Elizabeth Roth, Daniel Maier, Michelle R. Jacobs, Beth Hagesfeld, Ketrin Lengu, Alice Costiuc, and Andrea Barkoukis Gefteas in participant recruitment, assessment, and data coding. We also acknowledge the contributions of our colleague, Maureen Hack, M.B., Ch.B. (deceased), in study design and implementation. The authors have no conflicts to declare.

SUPPLEMENTARY MATERIAL

Supplementary material can be found online. Please visit journals.cambridge.org/jid_INS. https://doi.org/10.1017/S1355617719000080

REFERENCES

Aarnousde-Moens, C. S. H., Weisglas-Kuperus, N., van Goudoever, J. B., & Oosterlaan, J. (2009). Meta-analysis of neurobehavioral outcomes in very preterm and/or very low birth weight children. *Pediatrics*, *124*, 717–7128.

Achenbach, T. M., & Rescorla, L. A. *Manual for the ASEBA school-age forms and profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families; 2001.

Andreias, L., Borawski, E., Schluchter, M., Taylor, H. G., Klein, N., & Hack, M. (2010). Neighborhood influences on the academic achievement of extremely low birth weight children. *Journal of Pediatric Psychology*, *35*(3), 275–283.

Aylward, G. P. (2005). Neurodevelopmental outcomes of infants born prematurely. *Journal of Developmental and Behavioral Pediatrics*, *26*, 427–440.

Barnett, M., Tusor, N., Ball, G., Chew, A., Falconer, S., Aljabar, P., … Counsell, S. J. (2018). Exploring the multiple-hit theory of preterm white matter damage using diffusion MRI. *NeuroImage: Clinical*, *17*, 596–606.

Baron, I. S., Erickson, K., Ahronovich, M. D., Baker, R., & Litman, F. R. (2011). Neuropsychological and behavioral outcomes of extremely low birth weight at age three. *Developmental Neuropsychology*, *36*, 5–21.

Bayley, N. (1993). *Bayley Scales of Infant Development, 2nd ed*. San Antonio, TX: Psychological Corporation.

Beery, K. E., & Beery, N. A. (2004). *The Beery-Buktenica Development Test of Visual-Motor Integration: Beery VMI, administration, scoring, and teaching manual* (5th Ed.). Minneapolis, MN: NCS Pearson.

Bradley, R. H., Caldwell, B. M., Rock, S. L., Hamrick, H. M., & Harris, P. (1988). Home observations for measurement of the environment: Development of home inventory for use with families having children 6 to 10 years old. *Contemporary Educational Psychology*, *13*, 58–71.

Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology*, *53*, 371–399.

Bradley, R. H., Whiteside, L., Mundfrom, D. J., Casey, P. H., Kelleher, K. J., & Pope, S. K. (1994). Contribution to early intervention and early caregiving experiences to resilience in low-birthweight, premature children living in poverty. *Journal of Clinical Psychology*, *23*, 425–434.

Bruininks, R. H., & Bruininks, B. D. (2005). *BOT-2: Bruininks-Oseretsky Test of Motor Proficiency* (2nd ed.). Circle Pines, MN: American Guidance Service.

Bryck, R. L., & Fisher, P. A. (2012). Training the brain: Practical applications of neural plasticity from the intersection of cognitive neuroscience, developmental psychology, and prevention science. *American Psychologist*, *67*(2), 87–100.

Brydges, C. R., Landes, J. K., Reid, C. L., Campbell, C., French, N., & Anderson, M. (2018). Cognitive outcomes in children and adolescents born very preterm: A meta-analysis. *Developmental Medicine and Child Neurology*, *60*(15), 452–468.

Burchinal, M., Roberts, J. E., Zeisel, S. A., Hennon, E. A., & Hooper, S. (2006). Social risk and protective child, parenting, and child care factors in early elementary school years. *Parenting: Science and Practice*, *6*(1), 79–113.

Cicchetti, D. (2013). Annual research review: Resilient functioning in maltreated children – past, present, and future perspectives. *Journal of Child Psychology and Psychiatry*, *54*(4), 402–422.

Clark, C. A. C., & Woodward, L. J. (2015). Relation of perinatal risk and early parenting to executive control at the transition to school. *Developmental Science*, *18*(4), 525–542.

Clark, C. A. C., Woodward, L. J., Horwood, L. J., & Moor, S. (2008). Development of emotional and behavioral regulation in children born extremely preterm and very preterm: Biological and social influences. *Child Development*, *79*(5), 1444–1462.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*, 155–159.

Derogatis, L., & Melisaratos, N. (1983). The brief symptom inventory: An introductory report. *Psychological Medicine*, *13*, 595–605.

Diggle, P. J., Liang, K-Y., & Zeger, S. L. (1994). *Analysis of longitudinal data*. New York: Oxford University Press.

Ebesutani, C., Bernstein, A., Nakamura, B. J., Chorpita, B. F., Higa-McMillan, C. K., & Weisz, J. R. (2010). Concurrent validity of the Child Behavior Checklist DSM-Oriented scales: Correspondence with SDM diagnoses and comparison to syndrome scales. *Journal of Psychopathology and Behavioral Assessment*, *32*, 373–384.

Farah, M. J. (2017). The neuroscience of socioeconomic status: Correlates, causes, and consequences. *Neuron*, *96*, 56–71.

Garfield, C. F., Karbownik, K., Murthy, K., Falciglia, G., Guryan, J., Figlio, D. N., Roth, J. (2017). Educational performance of children born prematurely. *JAMA Pediatrics*, *171*(8), 764–770.

Gargus, R. A., Vohr, B. R., Tyson, J. E., High, P., Higgins, R. D., Wrage, L. A., & Poole, K. (2009). Unimpaired outcomes for extremely low birth weight infants at 18 to 22 months. *Pediatrics*, *124*, 112–121.

Gerard, A. B. (1994). *Parent-Child Relationship Inventory (PCRI): Manual*. Los Angeles, CA: Western Psychological Services.

Gioia, G., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). *BRIEF – Behavior Rating Inventory of Executive Function, Professional manual*. Odessa, FL: Psychological Assessment Resources; 2000.

Gonzalez, L. M., Anderson, V. A., Wood, S. J., Mitchell, A., & Harvey, A. S. (2007). The localization and lateralization of memory deficits in children with temporal lobe epilepsy. *Epilepsia*, *48*,124–132.

Greenley, R. N., Taylor, H. G., Drotar, D., & Minich, N. M. (2007). Longitudinal relationships between early adolescent family functioning and youth adjustment: An examination of the moderating role of very low birth weight. *Journal of Pediatric Psychology*, *32*(4), 453–462.

Griffin, E. A., & Morrison, F. J. (1997). The unique contribution of home literacy environment to differences in early literacy skills. *Early Child Development and Care*, *127-128*, 233–242.

Gross, S. J., Mettelman, B. B., Dye, T. D., & Slagle, T. A. (2001). Impact of family structure and stability on academic outcome in preterm children at 10 years of age. *Journal of Pediatrics*, *138*(2), 169–175

Hair, N. L., Hanson, J. L., Wolfe, B. L., & Pollack, S. D. (2015). Association of child poverty, brain development, and academic achievement. *JAMA Pediatrics*, *169*(9), 822–829.

Hargrove, D. S., & O'Dell, S. (1999). Book review: Parent-Child Relationship Inventory (PCRI). *Journal of Psychoeducational Assessment*, *17*, 167–170.

Hopp, C. A., & Baron, E. S. (2017). Birth at 22 gestational weeks: Case report of cognitive resilience. *The Clinical Neuropsychologist*, *31*(2), 471–486.

Inder, T. E., Wells, S. J., Mogridge, N. B., Spencer, C., & Volpe, J. J. (2003). Defining the nature of the cerebral abnormalities in the premature infant: A qualitative magnetic resonance imaging study. *Journal of Pediatrics*, *143*, 171–179.

Jacobson, J. L., & Jacobson, S. W. (1996). Methodological considerations in behavioral toxicology in infants and children. *Developmental Psychology*, *32*(3), 390–403.

Jaekel, J., Pluess, M., Belsky, J., & Wolke, D. (2015). Effects of maternal sensitivity on low birth weight children's academic achievement: A test of differential susceptibility versus diathesis stress. *Journal of Child Psychology and Psychiatry*, *56* (6), 693–701.

Jaffe, S. R. (2007). Sensitive, stimulating caregiving predicts cognitive and behavioral resilience in neurodevelopmentally at-risk infants. *Development and Psychopathology*, *19*, 631–647.

Johnson, S. (2007). Cognitive and behavioral outcomes following very preterm birth. *Seminars in Fetal and Neonatal Medicine*, *12*, 363–373.

Johnson, S., Wolke, D., Hennessy, E., & Marlow, N. (2011). Educational outcomes in extremely preterm children: Neuropsychologic correlates and predictors of attainment. *Developmental Neuropsychology*, *336*(1), 74–95.

Jolles, D. D., & Crone, E. A. (2012). Training the developing brain: A neurocognitive perspective. *Frontiers in Human Neuroscience*, *6*(76), 1–13.

Joseph, R. M., O'Shea, T. M., Allred, E. N., Heeren, T., & Kuban, K. K. (2017). Maternal educational status at birth, maternal educational advancement, and neurocognitive outcomes at age 10 years among children born extremely preterm. *Pediatric Research,* advance online publication 22 November. doi:10.1038/pr2017.267

Lai, W. W., O'Mahony, M., & Mulligan, A. (2015). A telephone interview version of the middle childhood home observation measurement of the environment. *Child: Care, Health and Development*, *41*(6), 1152–1160.

Landry, S. H., Smith, K. E., & Swank, P. R. (2006). Responsive parenting: Establishing early foundations for social, communication, and independent problem-solving skills. *Developmental Psychology*, *42*(4), 627–642.

Linares, T. J., Singer, L. T., Kirchner, H. L., Short, E. J., Min, M. O., Hussey, P., & Minnes, S. (2006). Mental health outcomes of cocaine-exposed children at 6 years of age. *Journal of Pediatric Psychology*, *31*(1), 85–97.

Litt, J., Taylor, H. G., Klein, N., & Hack, M. (2005). Learning disabilities in children with very low birthweight: Prevalence, neuropsychological correlates, and educational interventions. *Journal of Learning Disabilities*, *38*, 130–141.

Luu, T. M., Vohr, B. R., Allan, W., Schneider, K. C., & Ment, L. R. (2011). Evidence for catch-up in cognition and receptive vocabulary among adolescents born very preterm. *Pediatrics*, *128*(2), 313–322.

Luthar, S. S., Cicchetti, D., & Becker, B. (2000). The construct of resilience: A critical evaluation and guidelines for future work. *Child Development*, *71*(3), 543–562.

Masten, A. S. (2001). Ordinary magic: Resilience processes in development. *American Psychologist*, *56*(3), 227–238.

Masten, A. S. (2011). Resilience in children threatened by extreme adversity: Frameworks for research, practice, and translational synergy. *Development and Psychopathology*, *23*, 493–506.

Masten, A. S. (2014). *Ordinary magic: Resilience in development*. New York: Guilford.

Masten, A. S., & Coatsworth, J. D. (1998). The developmental of competence in favorable and unfavorable environments: Lessons from research on successful children. *American Psychologist*, *53* (2), 205–220.

Masten, A. S., Hubbard, J. J., Gest, S. D., Tellegen, A., Garmezy, N., & Ramirez, M. (1999). Competence in the context of adversity: Pathways to resilience and maladaptation from childhood to late adolescence. *Development and Psychopathology*, *11*, 143–169.

Masten, A. S., Garmezy, N., Tellegen, A., Pellegrini, D. S., Larkin, K., & Larsen, A. (1988). Competence and stress in school children: The moderating effects of individual and family qualities. *Journal of Child Psychology and Psychiatry*, *29*(6), 745–764.

Merrel, K. *Preschool and Kindergarten Behavior Scales—Second edition.* Austin, TX: PRO-ED; 2002.

Milgrom, J., Newnham, C., Anderson, P. J., Doyle, L. W., Gemmill, A. W., Lee, K., . . . Inder, T. (2010). Early sensitivity training for parents of preterm infants: Impact on the developing brain. *Pediatric Research*, *67*, 330–335.

Miller, I., Bishop, D., Epstein, N., & Keitner, G. (1985). The McMaster Family Assessment Device: Reliability and validity. *Journal of Marital and Family Therapy*, *11*, 345–356.

Moos, R., & Moos, B. (1994). *Life Stressors and Social Resources Inventory—Adult Form: Professional manual*. Odessa, FL: Psychological Assessment Resources.

Nakamura, B. J., Ebesutani, C., Bernstein, A., & Chorpita, B. F. (2009). A psychometric analysis of the Child Behavior Checklist DSM-Oriented Scales. *Journal of Psychopathology and Behavioral Assessment*, *31*, 178–189.

Nelson, J. M., Choi, H-J., Clark, C. A. C., James, T. D., Fang, H., Wiebe, S. A., & Espy, K. A. (2015). Sociodemographic risk and early environmental factors that contribute to resilience in executive control: A factor mixture model of 3-years-olds. *Child Neuropsychology*, *21*(3-4), 354–378.

Noble, K. G., Houston, S. M., Brito, N. H., Bartsch, H., Kan, E., Kuperman, J. M., . . . Sowell, E. R. (2015). Family income, parental education and brain structure in children and adolescents. *Nature Neuroscience*, *18*(5), 773–780.

Orchinik, L. J., Taylor, H. G., Espy, K. A., Minich, N., Klein, N, Sheffield, T., & Hack, M. (2011). Cognitive abilities in extremely preterm/extremely low birth weight children in kindergarten. *Journal of the International Neuropsychological Society*, *17*, 1067–1079.

Poehlmann-Tynan, J., Gerstein, E. D., Burnson, C., Weymouth, L., Bolt, D. M., Maleck, S., & Schwichtenberg, A. J. (2015). Risk and resilience in preterm children at age 6. *Development and Psychopathology*, *27*, 843–858.

Rogers, E. E., & Hintz, S. R. (2016). Early neurodevelopmental outcomes of extremely preterm infants. *Seminars in Perinatology*, *40*, 497–509.

Rutter, M. (1987). Psychosocial resilience and protective mechanisms. *American Journal of Orthopsychiatry*, *57*(3), 316–331.

Rutter, M. (2013). Annual research review: Resilience – clinical implications. *Journal of Child Psychology and Psychiatry*, *54*(4), 474–487.

Rutter, M., & Silberg, J. (2002). Gene-environment interplay in relation to emotional and behavioral disturbance. *Annual Review of Psychology*, *53*, 463–490.

Scott, M. N., Taylor, H. G., Fristad, M. A., Klein, N., Espy, K. A., Minich, N., & Hack, M. (2012). Behavior disorders in extremely preterm/extremely low birth weight children in kindergarten. *Journal of Developmental & Behavioral Pediatrics*, *33*, 202–213.

Stein, R. E. K., & Jessop, D. J. (2003). The Impact on Family Scale revisited: Further psychometric data. *Journal of Developmental and Behavioral Pediatrics*, *24*, 9–16.

Stern, Y. (2009). Cognitive reserve. *Neuropsychologia*, *47*, 2015–2028.

Stiles, J., Reilly, J., Paul, B., & Moses, P. (2005). Cognitive development following early brain injury: Evidence for neural adaption. *Trends in Cognitive Sciences*, *9*, 136–143.

Taylor, H. G., Klein, N., Anselmo, M. G., Minich, N., Espy, K. A., & Hack, M. (2011). Learning problems in kindergarten children with extremely preterm birth. *Archives of Pediatrics & Adolescent Medicine*, *165*, 819–825.

Taylor, H. G., Klein, N., Drotar, D., Schluchter, M., & Hack, M. (2006). Consequences and risks of <1000-g birth weight for neuropsychological skills, achievement, and adaptive functioning. *Developmental and Behavioral Pediatrics*, *27*, 459–469.

Taylor, H. G., Klein, N., Espy, K. A., Schluchter, M., Minich, N., Stilp, R., & Hack, M. (2018). Effects of extreme prematurity and kindergarten neuropsychological skills on early academic progress. *Neuropsychology*, *32* (7), 809–821.

Taylor, H. G., Klein, N., & Hack, M. (2001). Long-term family outcomes for children with very low birth weights. *Archives of Pediatrics and Adolescent Medicine*, *155*, 155–161.

Taylor, H. G., Klein, N., Minich, N. M., & Hack, M. (2000). Middle-school-age outcomes in children with very low birthweight. *Child Development*, *71*(6), 1495–1511.

Taylor, H. G., Klein, N., Schatschneider, C., & Hack, M. (1998). Predictors of early school age outcomes in very low birth weight children. *Journal of Developmental and Behavioral Pediatrics*, *19*(4), 235–243.

Taylor, H. G., Minich, N. M., Klein, N., & Hack, M. (2004). Longitudinal outcomes of very low birth weight: Neuropsychological findings. *Journal of the International Neuropsychological Society*, *10*(2), 149–163.

Treyvaud, K., Inder, T. E., Lee, K. J., Northam, E. A., Doyle, L. W., & Anderson, P. J. (2012). Can the home environment promote resilience for children born very preterm in the context of social and medical risk? *Journal of Experimental Child Psychology*, *112*, 326–337.

Ursache, A., Noble, K. G., for the Pediatric Imaging, Neurocognition and Genetics Study. (2016). Socioeconomic status, white matter, and executive function in children. *Brain and Behavior*, *6* (10), e00531.

Vanderbilt-Adriance, E., & Shaw, D. S. (2008). Protective factors and the development of resilience in the context of neighborhood disadvantage. *Journal of Abnormal Child Psychology*, *36*, 887–901.

Wagner, R. K., Torgesen, C. A., & Rashotte, C. (1999). *Comprehensive test of phonological processing*. Austin, TX: Pro-Ed.

Williams, A. R., Piamjariyakul, U., Williams, P. D., Bruggeman, S. K., & Cabanela, R. L. (2006). Validity of the Revised Impact on Family (IOF) Scale. *Journal of Pediatrics*, *149*, 257–261.

Woodcock, R. W, McGrew, K. S., & Mather, N. (2001a). *Woodcock-Johnson III Tests of achievement*. Itasca., IL: Riverside.

Woodcock, R. W, McGrew, K. S., & Mather, N. (2001b). *Woodcock-Johnson III Tests of Cognitive Abilities*. Itasca., IL: Riverside.

Wolke, D., Jaekel, J., Hall, J., & Baumann, N. (2013). Effects of sensitive parenting on academic resilience of very preterm and very low birth weight adolescents. *Journal of Adolescent Health*, *53*, 642–647.

Woodward, L.J., Anderson, P.J., Austin, N.C., Howard, K., & Inder, T.E. (2006). Neonatal MRI to predict neurodevelopment outcomes in preterm infants. *New England Journal of Medicine*, *355*, 685–694.

Yudkin, P. L., Aboualfa, M., Eyre, J. A., Redman, C. W., & Wilkinson, A. R. (1987). New birthweight and head circumference centiles for gestational ages 34 to 42 weeks. *Early Human Development*, *15*, 45–52.