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Kindergarten Classroom Functioning of Extremely Preterm/ Extremely Low Birth Weight Children

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1. Introduction

Although advances in neonatal intensive care have increased survival rates among extremely preterm/extremely low birth weight (EPT/ELBW) infants, defined as those born with gestational age <28 weeks and/or <1000g birth weight [1], the survivors are susceptible to a variety of neurodevelopmental impairments. EPT/ELBW children have weaknesses relative to term-born normal birth weight (NBW) controls in IQ, expressive and receptive language skills, spatial reasoning, motor and visual-motor skills, and executive functioning [2-7]. Rates of behavior problems are as much as four times higher in EPT/ELBW children compared to normal birth weight (NBW) peers and include attention deficit hyperactivity disorder (ADHD), internalizing symptoms such as anxiety and depression, and difficulties in social functioning [8-10]. Formal tests of academic skill and teacher ratings of achievement also reveal academic weaknesses that are evident by early school age [11-12].

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Conflict of interest statement

The authors have not declared any conflict of interest related to the current report.

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Previous research on classroom behaviors reveal higher rates of off-task behavior and lower rates of task engagement in children with ADHD compared to peers without ADHD, suggesting that the latter classroom characteristics may contribute to the academic underachievement that frequently accompanies this disorder [13,14]. Studies of other student populations, including children with learning disabilities, report associations of reduced levels of academic responding with lower achievement test scores [15]. However, to our knowledge no studies have conducted direct observations of the classroom behaviors of EPT/ELBW children. As school performance and behavior in the early grades are associated with longer-term academic outcomes [16-18], information about how EPT/ELBW children function in their classrooms at school entry may reveal some of the antecedents for their persisting learning problems. This information may also suggest ways to identify the children most in need of intensive early educational interventions, with the potential for reducing future learning and social deficits [19-21].

The present study applied a classroom observational procedure referred to as ecobehavioral analysis to compare the classroom functioning of EPT/ELBW students during their first year in kindergarten to NBW classmates. In this procedure, observers code student and teacher behaviors and classroom ecology (i.e., type of classroom activity) across successive cycles of observation using a time-sampling method [22]. Our primary aims were to determine if and how the performance of kindergarten EPT/ELBW children differed from that of their NBW peers and identify individual characteristics related to more problematic classroom functioning within the EPT/ELBW group. Based on the cognitive, learning, and behavior problems of EPT/ELBW children at school entry [10,23,24], we hypothesized that they would require more teacher attention, display more off-task behavior, and exhibit less academic engagement in the classroom than their NBW classmates. Previous research suggests that the academic deficits in children with extreme prematurity, although variable, are related to multiple individual characteristics, including higher neonatal medical risk, early childhood neurodevelopmental impairment, low scores on tests of global cognitive ability and executive function, and behavior problems [6,24-29]. Thus, we further hypothesized associations of these characteristics with poorer classroom functioning within the EPT/ELBW group. In view of research relating higher academic achievement to classroom characteristics, such as more experienced teachers and smaller class size [30-33], we also explored associations of these factors with classroom functioning within the EPT/ELBW group.

2. Methods

2.1 Sample

Between January 1, 2001, and December 31, 2003, 246 children were born at <28 weeks' gestational age or birth weight <1000 g and admitted to the neonatal intensive care unit of Rainbow Babies and Children's Hospital. Of the 198 EPT/ELBW children who survived, 148 were enrolled in a larger project examining early school-age outcomes of extreme prematurity [24]. Difficulties locating families and moves out of the region were the major reasons for non-participation, and non-participants did not differ from participants in sex, race, or neonatal risk factors. EPT/ELBW children who were enrolled in full time special

education programs (n=17), home schooled (n=3), or lived >2 hours driving distance from the research center (n=5) were also excluded from the present study, with another 12 children excluded due to difficulties arranging for classroom observations. Most of the 17 children with full time special education had low cognitive ability (i.e., 13 scoring <70 on the brief test of intelligence described below or unable to complete standardized tests due to global developmental impairment). The total subset of 37 excluded children did not differ significantly from the 111 EPT/ELBW children included in this study in birth weight, gestational age, sex, race, age at assessment, or score on the intelligence measure but had a higher rate of neurosensory abnormalities [8 (22%) of the excluded EPT/ELBW children, all in full-time special education, compared to 8 (7%) of participants, $p<.05$].

NBW controls (n=110) were recruited by having each EPT/ELBW child's teacher distribute flyers about the project to parents of the child's classmates. The NBW child who was most similar to the EPT/ELBW child in age at anticipated assessment, sex, and ethnicity was then recruited from the classmates whose parents agreed to be contacted. In 18 cases in which we were unable to recruit a NBW match within the same classroom, the NBW control was recruited from another classroom in the same school or a demographically similar one.

Table 1 summarizes neonatal and demographic characteristics for the EPT/ELBW and NBW groups. The groups did not differ significantly in sex, race, age at the time of testing, time in school when teacher ratings were completed, or socioeconomic status (SES) as defined by a mean of the sample z scores for maternal education, caregiver occupation (averaged for two-parent households), and census-based median family income [24]. Although the groups were matched on age at assessment, each EPT/ELBW child had to be assessed before the NBW could be recruited, hence EPT/ELBW children were slightly older than NBW controls at the time of the classroom observations. The observations of EPT/ELBW children and their NBW matches were conducted either simultaneously (76 pairings) or in close temporal proximity, thus the length of time in kindergarten was similar for the two groups. The groups did not differ significantly in rates of preschool attendance (84% of EPT/ELBW group vs. 86% of NBW group) but 39 (35%) of the EPT/ELBW children compared to 12 (11%) of the NBW controls had individual education plans in kindergarten, $\chi^2(1, N = 221) = 18.27, p<.001$.

2.2 Procedures

Developmental assessments of EPT/ELBW children and matched NBW classmates were completed during a half-day session in our research offices. Children in both groups were administered tests of cognitive abilities and academic achievement by examiners not informed of the child's birth status while parents were interviewed and completed child behavior ratings [10,23,24]. Following assessment of both the NBW child and NBW classmate, research assistants who had not tested the children they were observing and were not informed of their birth status conducted the classroom observations of both children. The observations of each EPT/ELBW child and NBW classmate control were conducted simultaneously by two separate observers in most instances and within a few days of one another when simultaneous observations were not feasible. Teacher ratings of child behavior and learning progress for both children and data regarding teacher background and

classroom characteristics were mailed to the research office by the teacher or collected by research assistants during their visits to the school. The study protocol was IRB approved with written informed consent obtained from parents and teachers.

2.3 Measures

Classroom observations were made during 1-hour instructional periods in regular classrooms using the Ecobehavioral Assessment software for the Mainstream Version of the Code for Instructional Structure and Student Academic Response (MS-CISSAR) [22,34]. Using this program, behaviors or activities for each of three observational targets (child, teacher, and classroom) are coded in 20-second intervals in repeating 1-minute cycles on a laptop computer. The percent time for each code was prorated in the few instances (9 EPT/ELBW, 8 NBW) in which a full hour was not available for observation (range 32-56 minutes, mean 51.06, $SD=6.77$). Ecobehavioral analysis is a well validated procedure that has been used in previous classroom observational studies [22,35,36]. Data obtained from this method correlate with measures of academic achievement and reveal lower levels of academic responding in at-risk compared to typically developing children [22,37].

Event codes were examined for one teacher and three student behaviors, each defined in terms of the frequency (percent of 1-minute cycles) of occurrence of the behavior during the observational session. *Teacher focus on target* was coded when the teacher was directing individual attention to the child being observed (2% of observed cycles), with each such interaction also coded in terms of the nature of the interaction (disapproval, discipline, or management). *Competing responses* included any off-task behaviors, such as talking out of turn, breaking other class rules, or engaging in activities unrelated to the academic task. *Academic responding*, which provided an index of task engagement, was coded whenever the student responded directly to an academic task, as when reading from a book or writing answers on a worksheet. *Task management* included behaviors that were not direct responses to instruction but were preparatory to academic responses, such as attending to teacher instructions or moving from a desk to join a group. A higher frequency of teacher focus on target was assumed to reflect a more negative child trait, as children with learning difficulties might be expected to require more individual assistance. Because more frequent competing responses would interfere with learning, this measure was also assumed to assess a less favorable child trait. In contrast, more frequent academic responding and task management were considered as indications of more successful classroom functioning. Each of the latter three measures was coded across separately for whole classroom activities (53% of observed cycles), small group instruction (9%), and independent work (36%). Small group settings were observed for only 52 EPT/ELBW children and 42 NBW controls. The limited frequency of teacher focus on target precluded examination of this code by setting. Inter-rater reliability was documented by having two trained observers conduct dual observations of a subsample of 23 children. Percentage agreement across all observations of the four codes ranged from 97%-100% (κ 's .92-.97, all p 's < .001).

Other measures from the larger project were included to describe group differences and investigate associations of classroom functioning within the EPT/ELBW group with child, teacher, and classroom characteristics. Neonatal and early childhood characteristics

considered included neonatal risk factors (bronchopulmonary dysplasia, neonatal infection, severely abnormal cranial ultrasound, severe retinopathy of prematurity) and neurodevelopmental impairment at 20 months corrected age as defined by a neurosensory disorder or Mental Development Index <70 on the Bayley Scales of Infant Development [38] (Table 1). Child characteristics were assessed in both groups in kindergarten and included global cognitive ability as measured by the Brief Intellectual Ability (BIA) score from the Woodcock Johnson III Tests of Cognitive Abilities [39], executive function skills as measured by tests developed by co-author K. Espy [23], and teacher ratings of behavior, social competence, and learning progress (Table 2) [10,24]. The cognitive measures were selected based on their associations with academic performance [2,6,25-28]. Teacher ratings were used to determine if classroom functioning was related to teacher impressions of children's behavior and learning progress. Teacher and classroom characteristics considered were years of teaching and teacher education, the presence/absence of another adult in the classroom such as an aide or student teacher, and class size as defined by the number of students in the classroom. Teacher of EPT/ELBW children had an average of 16.7 years of teaching experience (SD = 10.4; range 1-40), with 71% possessing a Master's degree or equivalent. Another adult besides the teacher was present in 75% of the classrooms and mean class size was 20.9 children (SD = 4.1; range 11-41). These persons included co-teachers in 15% of classrooms, aides in 58%, interns in 14%, and parent volunteers in 29%.

2.4 Statistical analysis

Analysis of covariance (ANCOVA) was used to compare the EPT/ELBW and NBW groups on the cognitive tests, teacher ratings, and frequency of occurrence (% of observational cycles) of each of the four measures of student functioning. Because of the low frequency of teacher focus on target, codes for the nature of this interaction (disapproval, discipline, and management) were analyzed as having been observed at least once vs. not at all across the entire observation session. Raw scores for teacher focus on target and competing responses were converted using log and cube root transformations, respectively, to normalize these distributions. SES z score, race, sex, time in kindergarten, and age (non-normed tests, teacher ratings, and observations only) were included as covariates in the ANCOVAs. Linear regression analysis was conducted to examine associations of classroom functioning in the EPT/ELBW group with neonatal risk factors and early childhood neurodevelopmental impairment, performance on cognitive measures, teacher ratings of behavior problems, social competence, and learning progress, and teacher and classroom characteristics. Each of these factors was examined separately controlling for the above-noted covariates.

3. Results

3.1 Group Comparisons on Cognitive Tests and Teacher Ratings (Table 3)

Consistent with group differences reported previously for the total sample [10,23,24], the EPT/ELBW group had significantly lower scores on the cognitive tests, higher teacher ratings of behavior problems, and lower ratings of social competence and learning progress than the NBW group. Also paralleling previous findings [10], 24 (23%) of the EPT/ELBW group compared to 11 (10%) of NBW controls had teacher ratings on the DSM-Oriented

scales for inattentive, hyperactive, or combined ADHD falling in the borderline clinical range or higher (93%), $\chi^2(1, N=210)=6.41, p=.011$.

3.2 Group Comparisons on Measures of Classroom Functioning (Table 4)

ANCOVAs revealed significantly more frequent teacher focus on target for the EPT/ELBW group than for NBW classmates. For both groups, the majority of these 1-1 interactions with teachers involved instructional management. Competing responses by the student during whole class instruction were also more frequent for the EPT/ELBW group than the NBW group, indicating that the EPT/ELBW group was significantly more often off-task.

3.3 Factors Associated with Classroom Functioning within the EPT/ELBW Group (Table 5)

Less positive indications of classroom functioning as assessed by more teacher focus on target, more off-task behavior (competing responses), less academic responding, or less task management were associated with multiple child characteristics within the EPT/ELBW group. These characteristics included: higher neonatal risk; early childhood neurodevelopmental impairment; lower scores on the BIA and all tests of executive function; higher teacher ratings of attention problems, externalizing and antisocial behavior, and executive dysfunction on the BRIEF; and lower teacher ratings of social competence and learning progress in written expression. More years of teacher experience was associated with more academic responding during independent work, another adult in the classroom with less off-task behavior during whole classroom activities and more task management in small group settings, and a larger class size with less teacher focus on target.

Several findings were specific to the classroom setting or activity in which the child was engaged at the time of the observation. Group differences in competing responses were evident for whole classroom activities but not for independent work, and several associations of child characteristics with classroom functioning were significant for whole classroom activities or independent work but not across both these settings. Neither group differences nor associations of EPT/ELBW child characteristics with classroom functioning were found for small group settings. Less positive classroom functioning within the EPT/ELBW group was also more consistently related to lower scores on tests of executive function than to lower global cognitive ability as measured by the BIA score.

Unexpectedly, *more* task management for independent work was associated with: lower scores on one test of executive function; higher teacher ratings of attention problems, internalizing symptoms, and executive dysfunction on the BRIEF Metacognitive Index; lower teacher ratings of social competence; and less teacher experience. The latter associations raise the possibility that task management during independent work represented poorer classroom functioning. In support of this possibility, task management during independent work was negatively correlated with academic responding in this same setting ($r = -.86, p < .001$). Task management during independent work was not correlated with task management during whole classroom activities, suggesting that this measure reflects a setting-specific trait. Because children performed pre-assigned but self-directed and possibly less demanding tasks during independent work, task management in this context may have

reflected excessive activity not directed toward task completion, perhaps involving imitation of other students or repetition of familiar but non-task relevant activities [36].

4. Discussion

The findings confirm problems in the classroom functioning for EPT/ELBW children attending regular kindergarten classrooms. Compared to NBW classmate controls, EPT/ELBW children received more individualized instructional management from their teachers and were more often off-task. Although this is to our knowledge the first classroom observational study of EPT/ELBW children at school entry, group differences confirm expectations based on previous reports of cognitive, academic, and attention deficits in the same cohort [10,23,24]. The results failed to reveal group differences in behaviors involved in preparation for academic activities (i.e., task management) or in engagement in academic tasks (i.e., academic responding). However, indications of less positive functioning on all four observational measures were related to one or more child risk factors, including higher neonatal risk, early childhood neurodevelopmental impairment, lower scores on tests of executive function, higher teacher ratings of behavior and attention problems, and lower teacher ratings of social competence and learning progress. These associations varied in relation to whether observations were made during whole classroom activities or independent work, with no associations of child characteristics with classroom functioning found during small group sessions. The potential for closer monitoring or more structuring of student behavior by teachers or teaching assistants during these sessions may help account for the latter finding. More generally, the results suggest that problems in classroom functioning among EPT/ELBW children vary with instructional demands.

The findings confirm the hypothesis that EPT/ELBW children are at higher risk than their NBW peers for difficulties in meeting the instructional demands of the kindergarten classroom, and they raise the possibility that these difficulties may contribute to learning problems in this population. Associations of individual teacher attention, competing responses, and academic responding with teacher ratings of progress in written language and math skills support the relevance of classroom functioning for academic learning. Past research reveals that problems in adapting to classroom demands in the early grades, such as off-task behavior and lack of task engagement, also forecast later learning problems [17,18].

The results also indicate that some EPT/ELBW children have more difficulties than others in meeting classroom instructional demands. Associations of these difficulties with higher neonatal risk factors, lower scores of tests of executive function, and teacher-reported problems in behavior and social competence point to potential reasons for these problems and are consistent with research linking academic achievement in EPT/ELBW children to similar characteristics [25,26,28]. Although students with lower BIA scores received more individual teacher attention, only poorer performance on tests of executive function were related to more off-task behavior, fewer academic responses, and less task management. These results parallel other research showing that measures of executive function are more closely related to academic achievement than assessments of global cognitive ability and are consistent with prematurity-related brain insults to the periventricular region and to fronto-striatal and fronto-parietal circuits [6,11,23,27-29]. Screening for these characteristics in

kindergarten may be useful in determining which children are most deserving of specialized instructional interventions or of further evaluations to determine their needs. Students identified as having special needs may benefit from instructional approaches in the early grades aimed at decreasing off-task behavior and increasing academic engagement and executive functioning [36,43-47]. Given elevated rates of ADHD in this and other EPT/ELBW cohorts [10], interventions designed for the latter population would also be appropriate, with an emphasis on clear rules and performance monitoring, prompting, and positive feedback and rewards by teachers [48]. Findings showing that kindergarten is an important period of transition to the demands of more formal instruction suggest that such programs be implemented as soon as possible after school entry [49].

Associations of better classroom functioning in EPT/ELBW children with more years of experience by the teacher, the presence of another adult in the classroom besides the teacher, and small class size imply that the needs of EPT/ELBW children be considered within the wider context of school effectiveness [50,51]. These results are consistent with research on the broader student population indicating that more teacher experience is related to higher achievement and more time spent on academic activities, and that the availability of additional persons to work with children is related to ratings of the instructional climate [32,52,53]. The finding that less individual teacher attention was provided to EPT/ELBW children from larger classes is in line with evidence for negative associations of academic engagement and learning with larger class size and suggests that availability of specialized learning assistance varies with classroom structure [15,31,33,54].

Major strengths of the study include the use of a well-validated observational method, observation of EPT/ELBW children and matched NBW classmates by observers who were naïve to birth status, and the opportunity to examine classroom functioning in relation to multiple child and classroom characteristics. One limitation is that some teachers may have been aware of the birth status of the children. Although they were not directly informed of this and the study was not presented to them as one investigating the effects of preterm birth, this information may have been available to them from other sources. Knowledge of preterm birth status may have biased their ratings of the child's behavior and learning progress or contributed to the group differences in individual teacher attention. However, a potential teacher bias would not have affected observer coding of student behaviors or the results of ability testing. A second limitation is that EPT/ELBW children from the larger project who were in full-time special education classes were excluded from this study; thus the present sample cannot be considered representative of the broader population of these children. Although children in full-time special education would likely have even more learning problems than those included in this study, the findings apply only to EPT/ELBW children receiving instruction in regular kindergarten classrooms. A further limitation is that the sample for the larger project was drawn from a largely urban region. Although representative of EPT/ELBW children born within our area, caution is advised in generalizing the findings to other regional populations of children with extreme prematurity born in the US or other countries. Lastly, teacher and classroom characteristics were not comprehensively assessed and may have been confounded with other unmeasured factors, such as school resources or educational policies. The observed associations justify further

study of the relation of classroom-level factors to achievement in preterm children but are not definitive.

In summary, classroom observation of kindergarten EPT/ELBW children reveals that they receive more frequent individual teacher instruction and are more often off-task than their NBW classmates. These observations also confirm associations of neonatal risk factors, lower scores on tests of executive function, and teacher ratings of behavior and attention problems, executive dysfunction, and lower social competence with poorer classroom functioning. Information regarding neonatal risk, executive function skills, and classroom behavior may thus be useful in identifying the children in need of more intensive educational intervention. Early interventions directed at high-risk children are thus possible and have the potential to curtail longer-term learning problems. The present findings provide impetus for future studies of interventions targeted to the needs of EPT/ELBW students at school entry. Further research is also required to determine if difficulties in classroom functioning at school entry predict subsequent academic growth and to examine the persistence of these difficulties across grades.

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Highlights

- The effects of extreme prematurity include problems in classroom functioning at school entry.
- Observed differences compared to peers include more off-task behavior and teacher attention.
- Poor classroom functioning is associated with problems in cognition, behavior, and learning.
- Children with extreme prematurity require more instructional support than their peers.

Table 1

Birth status and demographic characteristics of extremely preterm/extremely low birth weight (EPT/ELBW) and term-born normal birth weight (NBW) groups.

Characteristic	EPT/ELBW group (n = 111)	NBW group (n = 110)
Birth status:		
Gestational age in weeks, mean (SD), range	26 (2) range: 23-31	>36
Birth weight in grams, mean (SD), range	818 (176) range: 485-1281	3386 (446) range: 2495 - 4508
Neonatal risk factors:		
Bronchopulmonary dysplasia (BPD), n (%)	54 (49%)	-
Neonatal Infection, n (%)	43 (39%)	-
Severely abnormal cranial ultrasound, n (%)	9 (8%)	-
Severe retinopathy of prematurity, n (%)	17 (16%)	-
Early childhood neurodevelopmental status:		
Neurosensory Abnormality, n (%)	8 (7%)	-
Neurodevelopmental Impairment, n (%)	42 (39%)	-
Demographic characteristics:		
Age in years at testing, mean (SD)	5.92 (.34)	5.97 (.31)
Months in school at testing, mean (SD) ^a	4.12 (2.13)	6.39 (1.72)
Age in years at observation, mean (SD) ^a	6.16 (.36)	6.01 (.30)
Months in school at observation, mean (SD)	7.01 (1.71)	6.94 (1.64)
Male sex	50 (45%)	50 (46%)
African American	70 (63%)	60 (55%)
Maternal education:		
<high school	15 (14%)	13 (12%)
High school or GED	23 (21%)	16 (15%)
>high school	73 (66%)	81 (74%)
Median family income, mean (SD)	58 (34)	56 (24)
SES z-score composite, mean (SD)	-.06 (1.04)	.08 (.97)

^aSignificant group difference, $p < .001$

Note: BPD defined by supplemental oxygen at 36 weeks corrected age; neonatal infection as septicemia or necrotizing enterocolitis; severe ultrasound abnormality as Grade III/IV intraventricular hemorrhage, periventricular leukomalacia, or ventricular dilation at discharge; severe retinopathy of prematurity as stage 4 or 5 retinopathy or treatment with cryotherapy or laser therapy; neurosensory abnormality as cerebral palsy (6 children), blindness (2 children, 1 with cerebral palsy), or deafness (1 child); neurodevelopmental impairment as any neurosensory abnormality or Mental Development Index of <70 on the Bayley Scales of Infant Development, 2nd edition [38] at 20 months' corrected age. The SES z-score composite is the average of the sample z scores for maternal education, caregiver occupation (averaged for two-parent households), and census-based median family income in thousands.

Table 2

Description of measures of child characteristics assessed in kindergarten.

Domain/test	Description	Characteristic assessed	Scores for analysis
Cognitive tests:			
WJ-III Brief Intellectual Ability (BIA) [38]	Composite of subtests Verbal Comprehension, Concept Formation, and Visual Matching	Global cognitive ability	Age-standardized score
Shape School, inhibition condition [22]	Naming of cartoon figures that have happy faces while inhibiting responses to sad faces	Response inhibition	Age-adjusted efficiency score: accuracy/time
Preschool Trials Test--Revised, inhibition condition [22]	Responding to (by stamping) a series of cartoons of dog bones by increasing size while ignoring corresponding (and previously relevant) cartoons of dogs	Response inhibition	Age-adjusted efficiency Score: $[1/\text{time}/(\text{square root}(\text{errors}+1))]$
Nebraska Barnyard [22]	Reproduction of name sequence of animal names on computer touch screen	Spatial working memory	Age-adjusted number of correct sequences
Test of Inhibition and Attention. Go No-Go and CPT conditions [22]	CPT task in which child computer space bar presses to cartoon sharks while pressing to "catch" other fish	Response inhibition and selective attention	Age-adjusted d' : $Z(\text{hit rate}) - Z(\text{false alarm rate})$ for Go No-Go and CPT conditions
Teacher ratings:			
Teacher's Report Form (TRF) [39]	Broad-band teacher rating of different types of child behavior problems	Attention Problems, Externalizing, and Internalizing scales	Age- and gender-adjusted T scores
BRIEF-Teacher version [40]	Teacher ratings of behavioral indications of problems in executive function	Behavior self-regulation and organizational/self-monitoring behaviors	Age- and gender-adjusted T scores for Behavioral Regulation Index and Metacognition Index
School Social Behavior Scales, 2 nd Ed. (SSBS-2) [41]	Teacher ratings of student social competence and antisocial behaviors	Peer relations, self-management, listening and completing work, as well as hostility, disruptiveness	Age-adjusted T scores for Social Competence and Antisocial Behavior scales
Teacher ratings of student learning progress [23]	Teacher ratings of student learning progress in written language and mathematic skills relative to curricular objectives	Learning progress rated as below by full grading period (0), below but by less the grading period (1), or at or above expectations (2)	Ratings for each of several objective summed to form totals for written language and mathematics

Note: The tests and ratings, including the measures of executive function developed by co-author K.A. Espy (Shape School, Preschool Trails Test—Revised, Nebraska Barnyard Test, Test of Inhibition and Attention) and Teacher rating of academic progress, are more fully described in previous reports [10,23,24]. $Z(p)$ in computing d' for the Test of Inhibition and Attention is the inverse of the cumulative Gaussian distribution. Scores on the tests of executive function were age-adjusted based on the relation of age to performance in the NBW group. Higher scores on all cognitive measures, SSBS-2 Social Competence, and teacher ratings of learning progress correspond to better outcomes, while higher scores on the TRF and BRIEF-Teacher version indicate more problems.

Abbreviations: WJ-III = Woodcock Johnson Tests of Cognitive Ability, 3rd Ed.; CPT: Continuous Performance Tests; BRIEF = Behavior Rating Inventory of Executive Function.

Table 3

Group differences on kindergarten cognitive tests and teacher ratings.

Domain/test	EPT/ELBW Group Adj M (se)	NBW Group Adj M (se)	Group main Effect, F (df)	p	ES
Cognitive tests:					
WJ-III BIA	89.33 (1.75)	104.35 (1.75)	F(1,212)=31.09	<.001	.82
Shape School, Inhibition	0.90 (0.03)	1.06 (0.03)	F(1,207)=9.02	.003	.45
Preschool Trials Test—Revised, Inhibition	3.56 (0.45)	6.05 (0.44)	F(1,200)=13.49	<.001	.56
Nebraska Barnyard	4.85 (0.28)	6.39 (0.27)	F(1,200)=13.33	<.001	.56
Test of Inhibition and Attention, Go No-Go	1.48 (0.10)	2.34 (0.10)	F(1,212)=28.47	<.001	.79
Test of Inhibition and Attention, CPT	2.35 (0.12)	3.43 (0.12)	F(1,212)=34.04	<.001	.87
Teacher ratings:					
TRF Attention Problems	56.62 (0.59)	53.28 (0.59)	F(1,203)=15.86	<.001	.56
TRF Externalizing	51.95 (0.84)	49.78 (0.83)	F(1,203)=3.35	.069	.26
TRF Internalizing	48.67 (0.84)	45.36 (0.83)	F(1,203)=7.90	.005	.39
BRIEF Behavior Regulation Index	54.03 (1.22)	50.89 (1.21)	F(1,205)=3.33	.069	.25
BRIEF Metacognition Index	58.62 (1.06)	49.14 (1.05)	F(1,205)=40.13	<.001	.88
SSBS-2, Social Competence	50.23 (0.80)	57.43 (0.80)	F(1,207)=40.38	<.001	.88
SSBS-2, Antisocial Behavior	46.11 (0.68)	45.19 (0.67)	F(1,207)=.93	.337	.13
Teacher rating of student learning progress in written language	6.78 (0.27)	8.93 (0.27)	F(1,205)=32.04	<.001	.78
Teacher rating of student learning progress in mathematics	4.96 (0.14)	5.84 (0.14)	F(1,205)=20.44	<.001	.63

Note: See Table 2 for description of tests and scores. Statistics from group main effects were from analysis of covariance, controlling for sex, race, and SES. An additional covariate in analysis of the cognitive tests included age at testing (non-age-normed tests only) and weeks in kindergarten [23]. Children unable to perform a given test due to low cognitive functioning were assigned the lowest possible score [23].

Abbreviations: Adj M (se) = mean adjusted for covariates (standard error); ES: effect size = difference in means/pooled SD; WJ-III BIA: Woodcock Johnson Tests of Cognitive Abilities, 3rd Ed., Brief Intellectual Ability; CPT: Continuous Performance Test; TRF: Teacher's Report Form; BRIEF: Behavior Rating Inventory of Executive Function; SSBS-2: School Social Behavior Scales, 2nd Ed.

Table 4

Differences between the extremely preterm/extremely low birth weight (EPT/ELBW) and term-born normal birth weight (NBW) groups in classroom observation measures.

Classroom Observational Code	EPT/ELBW group (n = 111) Adj M (se)	NBW group (n = 110) Adj M (se)	F (df) from ANCOVA	p	ES
Focus on Target	8.66 (.70)	5.34 (.71)	F (1, 214) = 12.75	<.001	.49
Competing response:					
Whole Class	15.58 (1.47)	11.43 (1.47)	F (1, 207) = 6.73	.010	.36
Small Group	8.79 (2.09)	8.35 (2.35)	F (1, 87) = .01	.930	.02
Independent Work	12.27 (1.41)	10.66 (1.40)	F (1, 202) = 1.30	.256	.16
Academic responding:					
Whole Class	17.74 (1.35)	20.34 (1.35)	F (1, 207) = 1.77	.184	.19
Small Group	37.88 (3.83)	37.95 (4.31)	F (1, 87) = .00	.991	.00
Independent Work	42.20 (2.10)	39.07 (2.09)	F (1, 202) = 1.05	.306	.15
Task management:					
Whole Class	73.23 (1.57)	71.82 (1.57)	F (1, 207) = .39	.534	.09
Small Group	58.78 (3.96)	57.25 (4.45)	F (1, 87) = .06	.807	.05
Independent Work	50.76 (2.07)	52.75 (2.06)	F (1, 202) = .44	.508	.09

Note: Results are from analysis of covariance of group differences in classroom codes (% of observational cycles the code was registered) controlling for socioeconomic status z-score, ethnicity, sex, time spent in kindergarten at observation, and age. To examine group differences raw scores for teacher focus on target and competing responses were converted using log and cube root transformations, respectively. Small group settings observed for a subset of sample (52 EPT/ELBW children and 42 NBW controls).

Abbreviations: Adj M (SE) = mean raw score adjusted for covariates (standard error); ANCOVA = analyses of covariance; ES = effect size as defined by Cohen's d = mean difference/pooled standard deviation.

Table 5

Child and classroom characteristics of extremely preterm/extremely low birth weight (EPT/ELBW) children significantly associated with observational codes ($p < .05$).

Observational Code	Associated Characteristics	beta (se)	p
Teacher focus on target:			
All settings	Severe ultrasound abnormality	15.81 (3.17)	.008
	Neurodevelopmental impairment	5.64 (1.82)	.010
	WJ-BIA	-.20 (.05)	.001
	Shape School Test, Inhibition	-1.73 (.72)	.022
	Preschool Trails Test, Inhibition	-3.15 (.98)	.009
	Nebraska Barnyard Test	-2.06 (.81)	.017
	Test of Inhibition and Attention, Go No-Go	-1.95 (.68)	.011
	Test of Inhibition and Attention, CPT	-2.33 (.60)	.001
	TRF Attention Problems	.49 (.13)	<.001
	TRF Externalizing	.31 (.11)	.001
	BRIEF Behavior Regulation Index	.29 (.07)	<.001
	BRIEF Metacognition Index	.31 (.07)	<.001
	SSBS-2 Social Competence Scale	-.34 (.10)	.002
	SSBS-2 Antisocial Behavior Scale	.31 (.13)	.008
	Teacher Rating of Student Progress, Written Expression	-.54 (.28)	.047
	Class size	-.65 (.22)	.001
Competing response:			
Whole class activities	Preschool Trails Test, Inhibition	-4.42 (1.76)	.011
	Nebraska Barnyard Test	-3.42 (1.48)	.010
	TRF Attention Problems	.78 (.22)	.004
	TRF Externalizing	.62 (.18)	.002
	BRIEF Behavior Regulation Index	.50 (.11)	.001
	BRIEF Metacognition Index	.41 (.13)	.005
	SSBS-2 Social Competence Scale	-.70 (.17)	.001
	SSBS-2 Antisocial Behavior Scale	.82 (.21)	.004
Independent work	Other adult besides teacher in classroom	-9.21 (3.67)	.013
	Preschool Trails Test, Inhibition	-4.90 (1.69)	.009
	TRF Attention Problems	1.12 (.20)	<.001
	TRF Externalizing	.81 (.16)	<.001
	BRIEF Behavior Regulation Index	.57 (.10)	<.001
	BRIEF Metacognition Index	.49 (.11)	<.001
	SSBS-2 Social Competence Scale	-.72 (.16)	<.001
	SSBS-2 Antisocial Behavior Scale	1.13 (.18)	<.001
	Teacher Rating of Student Progress, Written Expression	-1.05 (.47)	.019
	Teacher Rating of Student Progress, Math	-1.75 (.81)	.049
Academic responding:			
Whole class activities	SSBS-2 Antisocial Behavior Scale	-.34 (.15)	.025

Observational Code	Associated Characteristics	beta (se)	p
Independent work	Teacher Rating of Student Progress, Math	1.61 (.59)	.007
	Test of Inhibition and Attention, CPT	3.27 (1.56)	.039
	TRF Attention Problems	-1.10 (.30)	<.001
	TRF Internalizing	-.70 (.25)	.006
	TRF Externalizing	-.69 (.25)	.007
	BRIEF Behavior Regulation Index	-.52 (.16)	.001
	BRIEF Metacognition Index	-.71 (.16)	<.001
	SSBS-2 Social Competence Scale	.93 (.23)	<.001
	SSBS-2 Antisocial Behavior Scale	-1.01 (.28)	.001
Task Management:	Teacher years of experience	.57 (.22)	.010
	Whole class activities		
	Neonatal infection	-7.20 (3.07)	.021
	Preschool Trails Test, Inhibition	4.54 (1.56)	.005
	TRF Attention Problems	-.57 (.21)	.009
	BRIEF Behavior Regulation Index	-.25 (.11)	.029
	BRIEF Metacognition Index	-.28 (.12)	.021
	SSBS-2 Social Competence Scale	.44 (.17)	.011
	Small group		
Independent work	Other adult besides teacher in classroom	18.44 (9.04)	.048
	Test of Inhibition and Attention, CPT	-3.33 (1.51)	.030
	TRF Attention Problems	.77 (.30)	.012
	TRF Internalizing	.63 (.25)	.012
	BRIEF Metacognition Index	.57 (.16)	.001
	SSBS-2 Social Competence Scale	-.62 (.23)	.009
	Teacher years of experience	-.49 (.21)	.025

Note: Results are from regressions of classroom codes (% of observational cycles the code was registered) on each predictor considered separately controlling for socioeconomic status z-score, ethnicity, sex, time spent in kindergarten at observation, and age. Raw scores for teacher focus on target and competing responses were converted previous to analysis using log and cube root transformations, respectively.

Abbreviations: beta (se) = unstandardized betas and standard errors; severe ultrasound abnormality = severe abnormality on neonatal cranial ultrasound; neonatal infection = septicemia and necrotizing enterocolitis; neurodevelopmental impairment = cerebral palsy, vision or hearing impairment, or Mental Development Index <70 on Bayley Scales of Infant Development, 2nd Ed. [38] at 20 months corrected age; WJ-BIA = Woodcock Johnson Tests of Cognitive Abilities, 3rd Edition: Brief Intellectual Ability [39]; CPT: Continuous Performance Test; TRF = Teacher's Report Form [40]; BRIEF = Behavior Rating Inventory of Executive Function—Teacher's version [41]; SSBS-2 = School Social Behavior Scales, 2nd Ed. [42].