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ORIGINAL CONTRIBUTION

Nonverbal intelligence in young children with dysregulation: the Generation R Study

Maartje Basten · Jan van der Ende · Henning Tiemeier · Robert R. Althoff · Jolien Rijlaarsdam · Vincent W. V. Jaddoe · Albert Hofman · James J. Hudziak · Frank C. Verhulst · Tonya White

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Abstract Children meeting the Child Behavior Checklist Dysregulation Profile (CBCL-DP) suffer from high levels of co-occurring internalizing and externalizing problems. Little is known about the cognitive abilities of these children with CBCL-DP. We examined the relationship between CBCL-DP and nonverbal intelligence. Parents of 6,131 children from a population-based birth cohort, aged 5 through 7 years, reported problem behavior on the CBCL/1.5–5. The CBCL-DP was derived using latent profile analysis on the CBCL/1.5–5 syndrome scales. Nonverbal intelligence was assessed using the Snijders Oomen Nonverbal Intelligence Test 2.5-7-Revised. We examined the relationship between CBCL-DP and nonverbal intelligence using linear regression. Analyses were adjusted for parental intelligence, parental psychiatric symptoms, socio-economic status, and perinatal factors. In a subsample with diagnostic interview data, we tested if the results were independent of the presence of attention deficit hyperactivity disorder (ADHD) or autism spectrum disorders (ASD). The results showed that children meeting the CBCL-DP ($n = 110$, 1.8 %) had a 11.0 point lower nonverbal intelligence level than children without problems and 7.2–7.3 points lower nonverbal intelligence level than children meeting other profiles of problem behavior (all p values <0.001). After adjustment for covariates, children with CBCL-DP scored 8.3 points lower than children without problems ($p < 0.001$). The presence of ADHD or ASD did not account for the lower nonverbal intelligence in children with CBCL-DP. In conclusion, we found that children with CBCL-DP have a considerable lower nonverbal intelligence score. The CBCL-DP and nonverbal intelligence may share a common neurodevelopmental etiology.

Keywords CBCL-dysregulation profile · Nonverbal intelligence · Childhood · Neurodevelopment · General population

M. Basten · J. van der Ende (✉) · H. Tiemeier · R. R. Althoff · J. Rijlaarsdam · J. J. Hudziak · F. C. Verhulst · T. White
Department of Child and Adolescent Psychiatry/Psychology, Erasmus Medical Center, Sophia Children's Hospital, P.O. Box 2060, 3000 CB Rotterdam, The Netherlands
e-mail: jan.vanderende@erasmusmc.nl

M. Basten · J. Rijlaarsdam · V. W. V. Jaddoe
The Generation R Study Group, Erasmus Medical Center, Rotterdam, The Netherlands

H. Tiemeier · V. W. V. Jaddoe · A. Hofman
Department of Epidemiology, Erasmus Medical Center, Rotterdam, The Netherlands

H. Tiemeier
Department of Psychiatry, Erasmus Medical Center, Rotterdam, The Netherlands

R. R. Althoff · J. J. Hudziak
Vermont Center for Children, Youth, and Families, The University of Vermont, Burlington, VT, USA

V. W. V. Jaddoe
Department of Pediatrics, Erasmus Medical Center, Sophia Children's Hospital, Rotterdam, The Netherlands

T. White
Department of Radiology, Erasmus Medical Center, Rotterdam, The Netherlands

Introduction

Children with co-occurring internalizing and externalizing problems have high levels of impairment and are at high risk for psychiatric disorders in adulthood [1–3]. An empirically derived profile that describes children with co-occurring internalizing and externalizing problems is the Child Behavior Checklist Dysregulation Profile (CBCL-DP) [1, 4–6]. The CBCL-DP in school-age children and adolescents is operationalized by high scores on the anxious/depressed, attention problems, and aggressive behavior scales of the CBCL [7]. It was first thought that high levels on these three scales were specific for juvenile bipolar disorder [8], but later studies have shown that this profile identifies children with poor regulation of emotion, attention, and behavior [6]. Recently, we empirically identified a CBCL-DP on the preschool CBCL [9, 10]. In young children, this profile was characterized by a wider range of problems across the internalizing and externalizing domains. The CBCL-DP has been found to be highly heritable and stable over time and is related to social problems, school problems, and suicidality [4, 6, 11]. Studies in clinical or at risk samples have shown that the CBCL-DP is related to the presence of several psychiatric diagnoses, including attention deficit hyperactivity disorder (ADHD) or hyperkinetic disorder [12–14], anxiety disorder [13], conduct disorder [12, 14] and oppositional defiant disorder [14]. The poor outcomes of the CBCL-DP argue for further study of the mechanisms underlying this phenotype. So far, little is known as to what extent children with CBCL-DP experience cognitive impairment.

Impairment in cognitive functioning is a key characteristic of neurodevelopmental disorders. Neurodevelopmental disorders are a heterogeneous constellation of disorders that are marked by impairment in the growth and development of the brain, such as autism spectrum disorders (ASD) and ADHD. Impairment in cognitive functioning can involve specific deficits or more general impairment, which is often assessed using intelligence tests. For example, children with ADHD score on average 9 points lower on intelligence tests than healthy controls [15]. Many children with ASD have an intelligence level <70 [16, 17]. However, cognitive impairment is not limited to neurodevelopmental disorders. Population-based studies have shown that general measures of psychopathology, such as the CBCL total problems score, correlate mildly with lower intelligence level [18, 19]. Externalizing problems, including antisocial behavior and aggression, are also negatively related to intelligence level [19–22]. For internalizing problems, such as anxiety and depressive symptoms, mixed results have been found [19, 23, 24]. Co-occurring internalizing and externalizing problems tend to be more strongly related to a lower intelligence level than only internalizing or only externalizing problems; however, results have not been fully consistent [25–27]. The association between cognitive impairment and psychopathology has also been found in studies on children with intellectual disability. Children with an intelligence level between 30 and 60, as well as children with an intelligence level between 60 and 80, are more likely to experience emotional and behavioral problems than typically developing children [28].

A few studies have investigated the relation between CBCL-DP and cognitive impairment. Biederman et al. [29] found that children with bipolar disorder and CBCL-DP had a lower intelligence level than children with only bipolar disorder and healthy controls. Peyre et al. [30] compared children with ADHD and CBCL-DP to children with only ADHD on four cognitive subdomains: planning, flexibility, interference control, and sustained attention. No group differences were found. These studies were performed in clinical samples, which may have resulted in a selection towards more severely affected children. In addition, these studies did not control for any potential confounding variables.

The goal of this study was to examine the relationship between CBCL-DP and intelligence in 5- to 7-year-old children from the general population. This study was conducted within Generation R, a multi-ethnic population-based cohort [31]. Because of differences in exposure to the Dutch language in young children from different ethnic minorities, we examined nonverbal intelligence. We investigated if children with CBCL-DP have a lower nonverbal intelligence level than children without problem behavior or children with predominantly internalizing or predominantly externalizing problems. We examined if an association between CBCL-DP and a lower nonverbal intelligence level is independent of the intelligence level of the parents. If children with CBCL-DP have a lower nonverbal intelligence level than what would be expected based on the intelligence level of their parents, this may point toward altered trajectories of typical brain development. As measures of parental intelligence we examined maternal nonverbal intelligence and paternal education level. We also tested if a relationship between CBCL-DP and nonverbal intelligence is independent of parental psychopathology and perinatal factors that are related to intelligence, such as maternal alcohol use during pregnancy, child's birth weight, and gestational age at birth [32]. We hypothesized that children with CBCL-DP have a lower nonverbal intelligence than children without problem behavior or children with predominantly internalizing or externalizing problems. In addition, we expected that the nonverbal intelligence level in children with CBCL-DP is lower than what would be expected by parental intelligence. To examine the specificity of the association between CBCL-DP and nonverbal intelligence, we investigated if a lower nonverbal intelligence level in children with CBCL-DP is independent of (a) the presence of severe intellectual disabilities defined as a nonverbal intelligence level <70; (b) the presence of ADHD or ASD, two neurodevelopmental disorders that are known to be related to a lower intelligence level; and (c) the overall level of emotional and behavioral problems, measured with the CBCL total problems score.

Methods

Setting and population

This study was embedded in the Generation R Study, a population-based cohort from fetal life onwards in Rotterdam, the Netherlands. The Generation R Study has been described previously [31, 33]. Briefly, all pregnant women living in Rotterdam, the Netherlands, with an expected delivery date between April 2002 and January 2006 were invited to participate. The study was conducted in accordance with the guidelines proposed in the World Medical Association Declaration of Helsinki and was approved by the Medical Ethics Committee of the Erasmus Medical Center, Rotterdam. Written informed consent was obtained from all adult participants. At birth, 9,749 children participated in the study. When the children in the Generation R Study reached the age of 5–7 years, their primary caregivers received the Child Behavior Checklist for ages 1.5–5 (CBCL/1.5–5) and all children were invited to visit the research center where nonverbal intelligence was measured. We included all children for whom the CBCL/1.5–5 was completed and who were younger than 8 years, $n = 6{,}131$. Of this sample, nonverbal intelligence was measured in 5,083 (83 %) children. Table 1 presents sample characteristics.

A subsample was recruited for a psychiatric interview and a screening procedure for ASD. This sample was enriched for psychopathology by including all children within the top 15 % of the CBCL/1.5–5 total problems score or in the top 2 % on one of the CBCL/1.5–5 syndrome scales ($n = 1{,}080$). Also a random sample of children with scores below these cut points was recruited ($n = 327$). Interview and screening data were obtained for 786 children with high scores on the CBCL/1.5–5 and for 257 children with low scores (participation rate 74 %). Children participating in the psychiatric interview ($n = 1{,}043$) were more likely to be Dutch (55.8 vs. 42.3 %, $\chi^2 = 28$, $df = 2$, $p < 0.001$), to have a higher nonverbal intelligence level (100.7 vs. 95.9, $p < 0.001$), and to have a lower CBCL total problems score (37.5 vs. 41.3, $p = 0.002$) than non-participating children ($n = 364$).

Table 1 Sample characteristics

	$n = 6{,}131$
Age in years, mean (SD)	6.1 (0.4)
Gender (%)	
Girls	49.7
Boys	50.3
Birth weight in grams, mean (SD)	3,425 (575)
Apgar score at 5 min after birth, mean (SD)	9.6 (0.8)
Gestational age at birth in weeks, mean (SD)	39.8 (1.9)
Ethnicity (%)	
Dutch	61.7
Other Western	9.0
Non-Western	29.3
Maternal smoking during pregnancy	
Never smoked	77.7
Quit when pregnancy was known	7.8
Continued during pregnancy	14.5
Maternal drinking during pregnancy	
No drinking	41.5
Until pregnancy was known	13.7
Continued during pregnancy	44.8
Maternal age at birth in years, mean (SD)	31.1 (4.8)
Maternal APM score, mean (SD)	9.1 (2.3)
Paternal education level (%)	
High	55.3
Medium	26.9
Low	17.8
Maternal psychiatric symptoms, mean (SD)	0.22 (0.27)
Paternal psychiatric symptoms, mean (SD)	0.15 (0.21)
Family income (%)	
<1,600€	15.9
1,600–3,200€	33.4
>3,200€	50.7

CBCL-dysregulation profile

Emotional and behavioral problems were assessed using the Child Behavior Checklist for ages 1.5–5 (CBCL/1.5–5) [9]. The CBCL/1.5–5 was chosen because we expected the majority of the children to be younger than 6 years at assessment. At the end of the assessment, while the majority of the sample was 5 years old (58 %), some children were 6 (38 %) or 7 (4 %) years old. The CBCL/1.5–5 consists of 100 items. Based on the behavior of the child in the preceding 2 months, the primary caregiver (92.6 % mothers) rated each item as 0 for not true, 1 for somewhat or sometimes true, and 2 for very true or often true. Good reliability and validity have been reported for the CBCL/1.5–5 [9] and the scales were found to be generalizable across 23 societies [34]. In our sample, for all scales Cronbach's alphas were the same in 5 year-old children and in children older than 5, indicating that problems were also reliably measured in children older than 5. The CBCL-DP was derived using latent profile analysis, which has been described previously [10]. In short, latent profile analysis was performed on six syndrome scales of the CBCL/1.5–5: Emotionally Reactive, Anxious/Depressed, Somatic Complaints, and Withdrawn, which are part of the internalizing domain, and Attention Problems and Aggressive Behavior, which are part of the externalizing domain. Four profiles were identified. The CBCL-DP was characterized by high levels of problems across the range of both internalizing and externalizing problems and included 1.8 % of the sample. In addition, we identified an internalizing profile (5.3 %) with moderate levels of problems on the four internalizing syndrome scales, an externalizing/emotionally reactive profile (7.3 %) with moderate problems on the Attention Problems, Aggressive Behavior and Emotionally reactive scales, and a no problems profile (85.6 %). For analysis we used a group membership variable that was based on the most likely latent profile membership for each child. This was justified because entropy was high at 0.98 [35].

Nonverbal intelligence

A nonverbal intelligence test was chosen to minimize bias by possible differences in Dutch language abilities in non-Dutch children. We used the Snijders–Oomen Nonverbal Intelligence Test 2.5-7-Revised (SON-R 2.5-7) [36], a reliable and valid measure [36–38]. Spoken or written language is not required for this test and instructions can also be given non-verbally. The total score of the SON-R 2.5-7 and the performance IQ score of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI-R) have been found to correlate 0.60–0.83 [36–38]. The SON-R 2.5-7 covers two domains: performance and reasoning. Because of time constraints, one performance subtest, i.e. Mosaics, and one reasoning subtest, i.e. Categories, were selected. These two subtests cover spatial insight (Mosaics) and abstract reasoning abilities (Categories). Among 4.5- to 7-year-old children in the norm sample ($n = 626$, mean age = 6.0 years, SD = 0.85), the two subtests showed a correlation of 0.36 [36]. Correlations between each subtest and the sum of the other subtests were 0.63 for Mosaics and 0.47 for Categories and the correlation of the sum of these two subtests with the total SON-R 2.5-7 score was 0.86 (P. Tellegen, personal communication, 7 March 2011). The test was administered by trained research assistants. Raw subtest scores were transformed according to population- and age-specific norms with a mean value of 100 and an SD of 15. We found a correlation of 0.31 between the subtests. In line with the guidelines of the manual only the total SON-R 2.5-7 score was used. During the assessment, research assistants also observed concentration, motivation, collaboration, and understanding of the test. Based on these observations a compliance variable was defined with two categories 'good test compliance' and 'variable to bad test compliance'.

Covariates

Several child, parental, and perinatal characteristics were considered as possible explanatory variables. Birth weight and Apgar score at 5 min after birth were derived from medical records. Gestational age at birth was established using ultrasound measures during pregnancy. Child's ethnicity, maternal age, and maternal prenatal smoking and drinking were obtained by questionnaires during pregnancy. Ethnicity was based on country of birth of the parents and was defined into Dutch, other Western, or non-Western. Maternal alcohol use was categorized into 'never drank in pregnancy', 'drank until pregnancy was known', and 'continued to drink during pregnancy'. Maternal smoking was categorized into 'never smoked during pregnancy', 'smoked until pregnancy was known', and 'continued smoking during pregnancy'. Maternal and paternal psychiatric symptoms were assessed at 20 weeks of pregnancy and when the child was 3 years old using the Brief Symptom Inventory (BSI), a validated self-report questionnaire [39, 40]. At 20 weeks of pregnancy the complete 53-item questionnaire was assessed, while at 3 years a short form was used, including the Depression, Hostility, Anxiety, and Interpersonal sensitivity subscales (21 items). We computed the Global Severity Index (GSI) [39], which we defined as the average item score across the two time points. Nonverbal intelligence of the mother was assessed during the visit to the research center at the age of 5–7 years using a computerized version of the Ravens Advanced Progressive Matrices Test, set I [41]. Set I consists of 12 items and has been shown to be a reliable and valid short form of the Raven's Progressive Matrices to asses nonverbal intelligence [42]. Paternal education and family income were obtained by questionnaire when the child was 5–7 years old. Paternal education was categorized into low (primary school or lower vocational education), medium (intermediate vocational education), and high (higher vocational education or university). Family income was defined by the total net month income of the household and categorized as follows: <1,600€ (below low income threshold for a family with two children), 1,600–3,200€, and >3,200€ (more than average family income).

ADHD and ASD

ADHD and ASD diagnoses were assessed to examine if the hypothesized relationship between CBCL-DP and nonverbal intelligence was independent of these diagnoses. ADHD diagnosis was assessed using the Diagnostic Interview Schedule for Children-young child version (DISC-YC) [43], which was administered to the primary caregiver. The DISC-YC is an adaptation of the DISC parent version and is suitable for children aged 3–8 years. The test–retest reliability for ADHD scales is 0.67 [44]. Children received an ADHD diagnosis if they fulfilled the criteria for the inattentive, hyperactive, or combined subtype, irrespective of impairment. The presence of ASD was assessed using the Social Communication Questionnaire (SCQ). The SCQ is a 40-item parent-reported screening measure that taps characteristic autistic behavior. The questionnaire is based on the ADI-R [45] and has established validity for screening of ASD [46]. Children with SCQ scores of 15 or above were considered as screen positives [47]. Data on ADHD diagnosis and ASD screening were available in 70 children with CBCL-DP (64 %), 179 children in the internalizing group (55 %), 275 children in the externalizing/emotionally reactive group (62 %), and 519 children in the no problems group (10 %).

Data analysis

To examine the relation between CBCL-DP and nonverbal intelligence, we performed linear regression with nonverbal intelligence of the child as the dependent variable and group membership as the independent variable. Group membership was dummy coded, with the no problems group as the reference category. To examine if the relationship between CBCL-DP and nonverbal intelligence was independent of parental and perinatal factors, we entered the covariates into the regression model.

Secondary analyses were conducted to further examine the association. To examine if the association was independent of the presence of severe intellectual disabilities, we repeated the analysis excluding children with a nonverbal intelligence score <70. To investigate if our results were independent of the presence of ADHD or ASD, we tested the relation between CBCL-DP and nonverbal intelligence among the subgroup of children who had received a psychiatric interview, excluding those children diagnosed with ADHD or screen positive for ASD. Finally, to examine whether the association was independent of the overall level of emotional and behavioral problems, we compared the nonverbal intelligence level between children with CBCL-DP and a group of children with the same level of CBCL total problems. We conducted all data analyses using SPSS (IBM SPSS Statistics version 20.0).

In the total sample, percentages of missing data were up to 23 % for covariates. To account for missing data on covariates and nonverbal intelligence, we imputed missing values using fully conditional specification method in SPSS and generated 20 imputed datasets. The imputation model included all variables that were used for further analyses. We added maternal education and a measure of child cognitive functioning at 3 years of age as additional indicators to improve the imputation model. To examine possible biases of the multiple imputations, analyses were repeated in the sample with complete nonverbal intelligence data ($n = 5{,}083$).

Non-response analysis

We compared prenatal child and maternal characteristics of the children included in the analysis ($n = 6{,}131$) with those excluded because of missing data on CBCL/1.5–5 ($n = 3{,}618$). Children of responding mothers were more likely to be Dutch (60.6 vs. 30.8 %, $\chi^2 = 1{,}062$, $df = 3$, $p < 0.001$). Responding mothers were more likely to be high educated (48.7 vs. 18.9 %, $\chi^2 = 1{,}250$, $df = 3$, $p < 0.001$) and to have a high family income (55.2 vs. 20.3 %, $\chi^2 = 1{,}328$, $df = 3$, $p < 0.001$).

Results

The mean nonverbal intelligence level of the total sample was 102.0 (SD = 14.9). The correlation between CBCL Total Problems and nonverbal intelligence was −0.16. Figure 1 presents nonverbal intelligence scores for the CBCL-DP group and the other groups. The CBCL-DP group scored 11.0 points lower than the no problems group (95 % CI −14.1; −7.9, $p < 0.001$), 7.2 points lower than the internalizing group (95 % CI −10.6; −3.7, $p < 0.001$), and 7.3 points lower than the externalizing/emotionally reactive group (95 % CI −10.6; −4.0, $p < 0.001$). Children in the internalizing and externalizing/emotionally reactive groups scored respectively 3.8 points (95 % CI −5.6; −2.1, $p < 0.001$) and 3.7 points (95 % CI −5.2; −2.1, $p < 0.001$) lower than the no problems group.

Table 2 provides differences in nonverbal intelligence scores between the CBCL-DP, internalizing, and externalizing/emotionally reactive groups and the no problems group after adjustment for child, parental, and perinatal factors. After adjusting for child age and gender, maternal cognitive ability, and paternal education level (model 2), the difference in nonverbal intelligence level between children with CBCL-DP and children with no problems was −8.6 points (95 % CI −11.6; −5.7, $p < 0.001$). When all covariates were entered (model 5) nonverbal intelligence level of children with CBCL-DP was 8.3 points

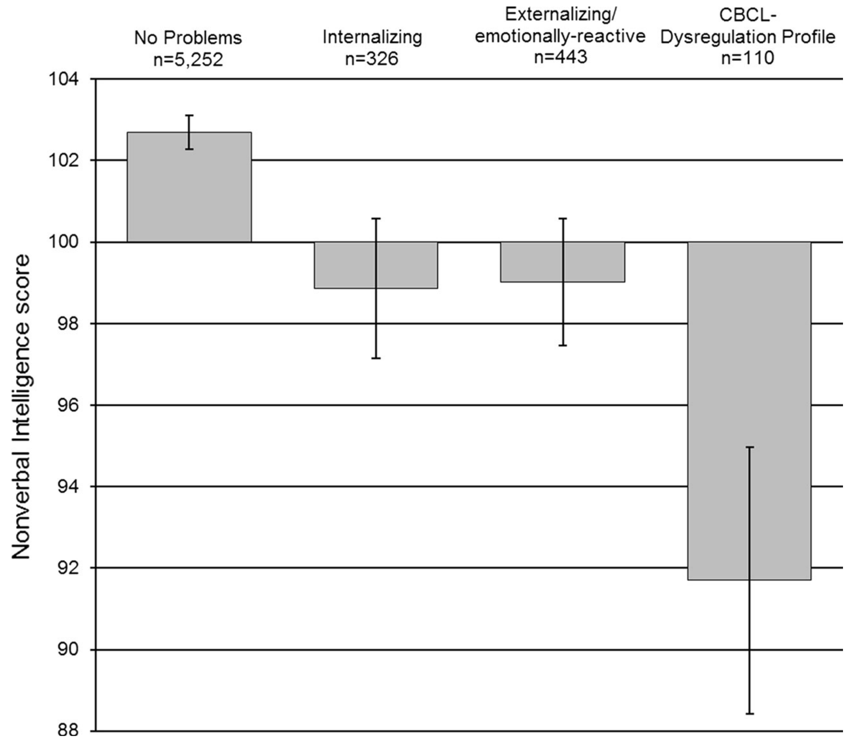

Fig. 1 Unadjusted nonverbal intelligence levels per group. *Error bars* represent 95 % confidence intervals

Table 2 Association between CBCL-dysregulation profile, internalizing, and externalizing/emotionally reactive profiles and nonverbal intelligence

	Internalizing ($n = 326$)			Externalizing/emotionally reactive ($n = 443$)			CBCL-dysregulation profile ($n = 110$)		
	B	95 % CI	*p* value	*B*	95 % CI	*p* value	*B*	95 % CI	*p* value
Model 1	−3.7	−5.5; −2.0	<0.001	−3.8	−5.3; −2.3	<0.001	−10.9	−14.0; −7.8	<0.001
Model 2	−2.0	−3.6; −0.3	0.020	−2.8	−4.3; −1.4	<0.001	−8.6	−11.6; −5.7	<0.001
Model 3	−2.9	−4.7; −1.1	0.001	−3.3	−4.9; −1.8	<0.001	−8.9	−12.1; −5.7	<0.001
Model 4	−2.9	−4.6; −1.2	0.001	−3.1	−4.5; −1.6	<0.001	−9.9	−12.9; −6.9	<0.001
Model 5	−1.4	−3.0; 0.3	0.105	−2.5	−3.9; −1.0	0.001	−8.3	−11.4; −5.3	<0.001

The no problems group ($n = 5{,}252$) is the reference group

Model 1: adjusted for age and gender; Model 2: adjusted for age, gender, maternal cognitive ability, and paternal education level; Model 3: adjusted for age, gender, maternal and paternal psychiatric symptoms; Model 4: adjusted for age, gender, maternal prenatal alcohol use and smoking, Apgar score, birth weight, and gestational age at birth; Model 5: adjusted for age, gender, maternal cognitive ability, paternal education level, maternal and paternal psychiatric symptoms, family income, maternal age, ethnicity child, maternal prenatal alcohol use and smoking, Apgar score, birth weight, and gestational age at birth

lower than children with no problems (95 % CI −11.4; −5.3, $p < 0.001$). Further adjustment for test compliance resulted in a 1 point decrease to a −7.3 points difference (95 % CI −10.3; −4.2, $p < 0.001$).

When all covariates were entered the nonverbal intelligence level of children with CBCL-DP also remained lower than the internalizing group (−7.0 points, 95 % CI −10.3; −3.7, $p < 0.001$) and externalizing/emotionally reactive group (−5.9 points, 95 % CI −9.1; −2.7, $p < 0.001$). The internalizing group no longer had a lower nonverbal intelligence score than the no problems group, while the lower nonverbal intelligence level for the externalizing/emotionally reactive group remained significant (−2.5 points, 95 % CI −3.9; −1.0, $p < 0.001$).

Secondary analyses conducted revealed comparable results. After the exclusion of children with a nonverbal intelligence score <70 the CBCL-DP group scored 9.5 points lower than the no problems group (95 % CI −12.5; −6.4, $p < 0.001$), 6.2 points lower than the internalizing group (95 % CI −9.7; −2.7, $p < 0.001$), and 6.6 points lower than the externalizing/emotionally reactive group (95 % CI −10.0; −3.2, $p < 0.001$).

We also examined if the lower nonverbal intelligence level in children with CBCL-DP was independent of an

ADHD or ASD diagnosis. A psychiatric interview was available in 70 children with CBCL-DP. Children with CBCL-DP and an ADHD diagnosis or screen positive for ASD ($n = 39$; mean nonverbal intelligence 91.0) did not significantly differ in nonverbal intelligence level from children with CBCL-DP only ($n = 31$; mean nonverbal intelligence 94.4; $B = -3.4$, 95 % CI −11.8; 5.0, $p = 0.431$). In the subsample of children with a psychiatric interview excluding children with ADHD or ASD, we found that the CBCL-DP group ($n = 31$) scored 8.1 points (95 % CI −13.9; −2.2, $p = 0.007$) lower than the no problems group ($n = 456$). The CBCL-DP group scored also 5.3 points (95 % CI −11.5; 0.9, $p = 0.095$) lower than the internalizing group ($n = 157$), and 5.1 points (95 % CI −11.3; 1.0, $p = 0.099$) lower than the externalizing/emotionally reactive group ($n = 190$); however, these differences were not significant.

Finally, we examined whether children with CBCL-DP had a lower nonverbal intelligence level than children with the same level of CBCL total problems. The first 49 children with the highest CBCL total problems score were all in the CBCL-DP group. For 52 children with CBCL-DP a child from the Internalizing or Externalizing/Emotionally reactive group was identified with the same score on the CBCL total problems scale (mean CBCL total problems score in both groups = 66.4). The nonverbal intelligence level for the 52 children with CBCL-DP was 3.0 points (95 % CI −9.4; 3.4, $p = 0.363$) lower than the group children without CBCL-DP. This difference was not significant.

All analyses were repeated in the subsample with complete data on nonverbal intelligence ($n = 5{,}083$). Similar results were found.

Discussion

This study examined the relationship between CBCL-DP and nonverbal intelligence in a large population-based study. Children with CBCL-DP had an 11-point lower nonverbal intelligence score than children without any emotional or behavioral problems and a 7-point lower score than children with moderate internalizing problems or moderate externalizing and emotionally reactive behavior. These differences remained after adjustment for parental cognitive and psychosocial functioning and perinatal factors. Interestingly, CBCL-DP remained related to a lower nonverbal intelligence after exclusion of children meeting criteria for ADHD or ASD.

To our knowledge, this is the first study that examined the relationship between CBCL-DP and cognitive abilities among children from the general population. Our results build on findings from a clinical study, which reported that children with both CBCL-DP and bipolar disorder had a lower nonverbal intelligence level than children with only bipolar disorder and controls [29]. The 11 points lower nonverbal intelligence level in children with CBCL-DP found in this study is comparable to the on average 9–10 points lower intelligence levels that have been reported for children with ADHD [15, 48] and for children with severe antisocial behavior [20, 21, 49].

One question arises as to whether the relationship between CBCL-DP and nonverbal intelligence is merely a global relationship with the total CBCL score. Indeed, children in the CBCL-DP group have the highest levels of problems across the internalizing and externalizing domain. Thus, it is difficult to examine to what extent the relation between the CBCL-DP and nonverbal intelligence is specific. We found a 3-point difference in nonverbal intelligence level between 52 children with CBCL-DP and 52 children without CBCL-DP but with the same score on the CBCL total problems scale. This difference was not significant, which may be explained by the small sample size. A difference of 3 points, which is equal to 0.2 standard deviation, suggests that a small difference remains.

A possible explanation for the relationship between CBCL-DP and nonverbal intelligence is that CBCL-DP and intelligence share a common neurodevelopmental etiology. Such a process has also been proposed in a model for the relationship between antisocial behavior and intelligence [49]. The interplay between genetic and environmental factors may result in altered trajectories of typical brain development, affecting both intelligence and behavior. Population-based twin studies have shown that the association between various forms of psychopathology and intelligence is largely explained by genetic factors. In 5-year-old children, 86 % of the relationship between ADHD and intelligence and 100 % of the relationship between antisocial behavior and intelligence have been shown to be accounted for by genetic influences [21, 48]. Similarly, genetic factors have been shown to account for 50–84 % of the relationship between overall levels of psychopathology and intelligence in twin studies [18, 50]. Environmental factors are likely to be highly important in moderating these genetic effects. Since we measured CBCL-DP and intelligence only at 5–7 years of age, we do not know when trajectories of children with CBCL-DP deviated from typical brain development.

Rutter and colleagues [51] proposed that neurodevelopmental disorders have eight main features: (1) a deviance in maturationally influenced psychological features; (2) cognitive impairment; (3) overlap with other neurodevelopmental disorders; (4) male preponderance; (5) strong genetic influences; (6) contributory environmental influences; (7) persistence into adulthood in combination with a decrease in impairment across age; and (8) no remissions and relapses. Our study and previous studies showed that CBCL-DP meets many of these characteristics. In this study, we found that CBCL-DP is related to a lower nonverbal intelligence level. Also considerable overlap with ADHD and ASD was found: 55 % of children met criteria for ADHD or were screen positive for ASD. Also, 66 % of children with CBCL-DP were boys [10] although mixed results regarding male preponderance have been found in other studies [5, 52]. In addition, several studies in a Dutch twin sample have shown that while the CBCL-DP is highly heritable, environmental factors also play a significant role [4, 52, 53]. We and others have also found that the CBCL-DP is stable over time [1, 53] and children meeting the profile likely continue having dysregulatory problems reflected by psychiatric disorders in adulthood [1, 13, 54]. These findings suggest that the CBCL-DP fits the pattern of a neurodevelopmental disorder. However, future studies should examine to what extent impairment in children with CBCL-DP lessens with age and if relapses and remissions occur.

Problems in self-regulation could also have interfered with test performance and have resulted in a lower nonverbal intelligence score. Moreover, attention problems may have led to lower scores. Children with CBCL-DP have also been shown to be less persistent [55]. In addition, decreased motivation, which is an important predictor for test performance [56], might have played a role in these children. In our analyses, however, the adjustment for observed test compliance resulted in only one-point difference in nonverbal intelligence. This is similar to a study on the relationship between ADHD and intelligence, where observed inattentive behavior explained only a two-point difference in intelligence level [48]. Dysregulated behavior could also interfere with learning in school or everyday life, with a subsequent decrease in intelligence scores. Alternatively, a lower intelligence level may cause CBCL-DP. For example, children with a lower intelligence level may experience more frustration in their daily lives that in turn results in dysregulated behavior.

A lower nonverbal intelligence level was also found in children in the group with moderate externalizing and emotionally reactive behavior, although the adjusted difference with children without problems was only −2.5 points. This is in line with population-based studies that found small correlations around −0.20 between externalizing behavior and intelligence [19, 21]. For the group of children with moderate internalizing problems the relationship with nonverbal intelligence no longer held after adjustment for covariates. Previous studies found mixed results regarding the relation between internalizing problems and intelligence [19, 23, 24]. Possibly, positive findings for a negative relationship between internalizing problems and intelligence in earlier studies were confounded by factors that accounted for the difference in intelligence level in our study.

The strengths of this study are the large number of participants and the population-based design. Other strengths are the empirically based method to define CBCL-DP and the many covariates that we controlled for, including parental cognitive functioning. Finally, the presence of psychiatric information in a subsample allowed us to study the relation between CBCL-DP and nonverbal intelligence independent of the presence of ADHD and ASD. There are also limitations to the study. We did not measure verbal intelligence. A nonverbal intelligence test was chosen to minimize bias by possible language problems in non-Dutch children (38 % of the sample). Because of time restrictions, we used an abbreviated version of the intelligence test. However, the two subtests used in this study were highly correlated with the total score on the nonverbal intelligence test. Another limitation is that the non-response analyses indicated that higher educated mothers and Dutch children were more likely to be included in the study, which resulted in an under-representation of more disadvantaged families.

In conclusion, this study showed that children with CBCL-DP have a considerable lower nonverbal intelligence level than children without problems or with other patterns of problem behavior. Impaired cognitive abilities place these children at risk for poor academic achievement. Understanding the underlying mechanisms will be important in designing interventions to help these children perform in academic environments. More in-depth neuropsychological testing is needed to understand if these children have a global impairment or impairments only within specific cognitive domains. Brain imaging studies can help to understand neurobiological underpinnings of CBCL-DP and differences in neurodevelopmental trajectories.

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Conflict of interest Dr. Verhulst is a contributing author of the Achenbach System of Empirically Based Assessment (ASEBA), from which he receives remuneration. Mses. Basten, and Rijlaarsdam, Mr. van der Ende, and Drs. Tiemeier, Althoff, Jaddoe, Hofman, Hudziak, and White declare that they have no conflict of interest.

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