Personality and Individual Differences 94 (2016) 366–371

Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

Emotional, behavioral and social difficulties among high-IQ children during the preschool period: Results of the EDEN mother–child cohort

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ARTICLE INFO

Article history:
Received 12 December 2015
Received in revised form 4 February 2016
Accepted 5 February 2016
Available online xxxx

Keywords:
Giftedness
Intelligence
Emotional difficulties
ADHD
Preschool period

ABSTRACT

Rationale: High intelligence may be associated with emotional, behavioral and social difficulties. However, this hypothesis is supported by little compelling, population-based evidence, and no study has been conducted during the preschool period with a population-based sample.
Method: Children (N = 1100) from the EDEN mother–child cohort were assessed at the age of 5–6 years. Behavioral, emotional and social problems (emotional symptoms, conduct problems, symptoms of hyperactivity/inattention, peer relationship problems and prosocial behavior) were measured using the parent-rated Strengths & Difficulties Questionnaires (SDQ). IQ scores were based on the WPPSI-III at 5–6 years. Relevant covariates for children's cognitive development were also collected.
Results: We found no significant differences in SDQ scores between gifted children (N = 23; Full Scale IQ > 130) and children with Full Scale IQ in the normal range (N = 1058 ≥ 70 and ≤130), except a marginally significant association between high-IQ and emotional difficulties at 5–6 years. Further sensitivity analyses did not support the association between high-IQ and emotional difficulties.
Discussion: During the preschool period, gifted children do not seem to manifest more behavioral, emotional and social problems than children with normal IQ.

1. Introduction

Giftedness, defined as high-IQ (usually, Full Scale IQ [FSIQ] above 130), is an adaptive advantage for problem-solving, and an ingredient of educational and professional achievement, but some authors suggest that it may also be a burden, leading to a series of difficulties in the emotional, behavioral and social domains. Indeed, it has previously been suggested that high intelligence is associated with a variety of negative emotional outcomes in children and adults, including depression and anxiety symptoms (Blaas, 2014; Harrison & Haneghan, 2011), attentional difficulties (Guénolé et al., 2015) and a range of relational difficulties (Cross & Cross, 2015). These results are frequently interpreted in light of Dąbrowski's theory (Dąbrowski, 1967, 1972), which links high intelligence with overexcitability. Following Dąbrowski, some authors have suggested that high intelligence children may lead to a feeling of being different and to problems of emotional and social adjustment (Piechowski, 2009).

However, the scientific literature on this topic remains largely inconsistent. This is particularly obvious in the case of anxiety. Some authors have reported increased anxiety among gifted children (Forsyth, 1987; Harrison & Haneghan, 2011). However, most researchers found either no link (Beer, 1991; Chuderski, 2015; Guénolé et al., 2013; Norman, Ramsay, Martray, & Roberts, 1999; Pufal-Struzik, 1999) or a reduced anxiety level among the gifted (Černova, 2005; Milgram & Milgram, 1976; Scholwinski & Reynolds, 1985; Shechtman & Silektor, 2012; Zeidner & Shani-Zinovich, 2011). In a recent meta-analysis, Martin, Burns, and Schonlau (2010) concluded that symptoms of anxiety (as well as depression) were less frequent among gifted children and adolescents than among the non-gifted (Martin et al., 2010). They also identified two main limitations of previous studies: (1) variability in definitions of giftedness and (2) sampling biases.

(1) Definitions of giftedness vary widely from a study to another. Although the most widespread definition is based on a Full Scale IQ [FSIQ] score, many authors include creativity, school

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http://dx.doi.org/10.1016/j.paid.2016.02.014
0191-8869/

performance, leadership or any combination of these in their definition. Those who based their definition of giftedness on IQ have chosen several thresholds: 120, 125, 130, 145 or even 160, even if the most frequent choice remains 130 (i.e., 2 standard deviations above the population mean). In a recent review, Carman (2013) showed that among 104 empirical published papers on giftedness, only 32% used this definition, sometimes with additional inclusion or exclusion criteria (Carman, 2013). In several cases, the definition of giftedness used by the authors is not even made explicit in the paper (Martin et al., 2010).

Some investigators, especially in clinical practice or those studying "twice exceptional" children (who are gifted and at the same time suffer from a specific learning disorder), have used a definition based on the maximum score among verbal and performance IQ (e.g., (Gilger, Talavage, & Olulade, 2013; Melogno, Pinto, & Levi, 2015). A gifted child is then defined as one with either a verbal IQ or a performance IQ above 130, irrespective of the FSIQ. This definition prevents psychologists from discarding highly intelligent children with a specific learning disorder that would only impair one of the two scores.

(2) The main challenge in interpreting results from studies on giftedness comes from sampling heterogeneity. Because obtaining a sample of gifted children without testing large populations is difficult, authors have used several methods that may be biased. Some used preselection by teachers (e.g. Chan, 2012), a method that biases the sample towards stereotypes shared by teachers. Some samples are recruited through clinical psychologists or even in psychiatry departments (e.g. Louis et al., 2003), leading to an increased rate of psychiatric disorders. Some used samples from special education schools for the gifted and talented, in which case gifted underachievers are probably underrepresented (e.g. Shechtman & Silektor, 2012). Martin et al. (2010) have expressed concern about the pervasiveness of biased towards those who had higher social, behavioral and emotional difficulties across the literature on giftedness (Martin et al., 2010).

They conclude that there is a need for studies based on broad samples of children recruited in the community.

Thus, our first goal is to evaluate characteristics of gifted children in a community setting. Second, we aim to investigate the association between high IQ and behavioral, emotional and/or social difficulties at an earlier age than usually examined. Indeed, for some children, the onset of emotional problems can be observed as early as the preschool years (Poulou, 2013). Kessler et al. (Kessler et al., 2005) reported that, in the National Comorbidity Survey Replication (NCS-R), 10% of individuals with anxiety disorders have their first symptoms at age 5 and 10% of individuals with impulse-control disorders (i.e., oppositional-defiant disorder, conduct disorder, Attention Deficit/Hyperactivity Disorder (ADHD) and intermittent explosive disorder) already have symptoms at the age of 6. Previous longitudinal community studies found a significant continuity for behavioral, emotional and/or social problems from the preschool to school-age period (McConaughy, Stanger, & Achenbach, 1992; Verhulst et al., 2009) and to early adolescence (Anselmi et al., 2008). Preschool is a particularly important period to examine the behavioral and emotional adaptation of children who are intellectually gifted because children of that age face new social challenges, new requirements in terms of behavioral regulation, new opportunities for boredom and frustration and therefore new opportunities for feeling socially or behaviorally ill-adjusted and for developing internalizing or externalizing symptoms.

In the present study, we used data from a large population-based sample of French children to address the question whether high-IQ children show increased symptoms of emotional, behavioral and social difficulties compared to children within the normal range of IQ. Because this sample is population-based, it does not present the usual selection biases affecting much of the literature on giftedness.

2. Method

2.1. Participants

We analyzed data from the EDEN prospective mother–child cohort study (Heude et al., 2015). The primary aim of the EDEN cohort was to identify prenatal and early postnatal nutritional, environmental and social determinants associated with children's health and their normal and pathological development. Pregnant women seen during a prenatal visit at the departments of Obstetrics and Gynecology of the French University Hospitals of Nancy and Poitiers before their twenty-fourth week of amenorrhea were invited to participate. Exclusion criteria included a history of diabetes, twin pregnancies, intention to deliver outside the university hospital or to move out of the study region within the next 3 years, and inability to speak French. The participation rate among eligible women was 53%. Enrolment started in February 2003 in Poitiers and in September 2003 in Nancy, lasted for 27 months in each center and resulted in the inclusion of 2002 pregnant women. Compared to the National Perinatal Survey (ENP) carried out among 14,482 women who delivered in France in 2003 (Blondel, Supernant, Du Mazaubrun, & Bréart, 2006), women participating in the EDEN study had similar sociodemographic characteristics except they had higher educational background (53.6% had a high-school diploma versus 42.6% in the ENP survey) and were more often employed (73.1% were employed during pregnancy cohort versus 66.0% in the ENP survey) (Heude et al., 2015). The study was approved by the Ethical Research Committee (Comité consultatif de protection des personnes dans la recherche biomédicale) of Bicêtre Hospital and by the Data Protection Authority (Commission Nationale de l'Informatique et des Libertés). Informed written consents was obtained from parents for themselves at the time of enrollment and for the newborn after delivery.

Among the 2002 women included in the EDEN study, 1907 mother–child pairs were still in the cohort at the time of delivery (Heude et al., 2015). In this longitudinal study, the attrition rate at 5–6 years was 39%.

2.2. Measures

2.2.1. IQ

At the age 5-to-6 years (mean age = 67.9 months; SD = 1.8), 1100 children were assessed using the Wechsler Preschool and Primary Scale of Intelligence 3rd Edition (WPPSI-III (Wechsler, 2002); using French norms). Children with a FSIQ score strictly higher than 130 were considered as gifted and those with a FSIQ strictly lower than 70 as disabled.

Compared to children who were not assessed with neuropsychological tests, the children included in our analyses significantly differ with regard to parental educational level ($p < 0.001$) and family income ($p < 0.001$).

2.2.2. Emotional and behavioral problems assessment

The Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997; Shojaei, Wazana, Pitrou, & Kovess, 2009) was used to measure emotional and behavioral problems when children were 5–6 years. The SDQ was completed by parents. The SDQ is a 25-item scale comprising five scores covering emotional problems (items about fears, worries, misery, nervousness and somatic symptoms), conduct problems (items about tantrums, obedience, fighting, lying and stealing), symptoms of hyperactivity/inattention (items on restlessness, fidgeting, the ability to concentrate, distractibility and impulsivity), peer relationships (items on popularity, victimization, isolation, friendship and the ability to relate to children as compared to adults), and pro-social behavior (items on

consideration of others, the ability to share, kindness to younger children, helpfulness to other children when distressed and willingness to comfort others). Answer options for each item are: 'Not true' 'Somewhat true' or 'Very true', scored 0, 1 or 2, yielding a total score ranging from 0 to 10 for each subscale. Higher scores represent worse functioning except for pro-social behavior. In the present data, the Cronbach's alphas for each SDQ scale at 5–6 years were as follows: 0.60 for emotional symptoms, 0.73 for conduct problems, 0.76 for hyperactivity/inattention, 0.54 for peer relationship problems and 0.69 for prosocial behavior. These reliability estimates were similar to those found in a representative sample of 1348 French children aged 6–11 years old (Shojaei et al., 2009).

2.2.3. Predictors of cognitive development

Gender, gestational age at birth and birthweight were collected from obstetrical records. Mothers completed questionnaires on tobacco and alcohol consumption during pregnancy (number of drinks per week) and their date of birth. Data on partial and exclusive breastfeeding duration were collected (Bernard et al., 2013). Maternal depression during pregnancy was assessed by the Center for Epidemiological Studies-Depression scale (CES-D) between 24 and 28 gestational weeks. A cut-off of 16 was used to define depression (Hann, Winter, & Jacobsen, 1999; Morin et al., 2011). We assessed postpartum depression status with the Edinburgh Postnatal Depression Scale at 4, 8 and 12 months. A cut-off of 13 was used to define depression (Adouard, Glangeaud-Freudenthal, & Golse, 2005; Teissedre & Chabrol, 2004) and with the CES-D at 3 and 5 years following delivery (a cut-off of 16 was also used to define depression). Mothers and fathers completed questionnaires on their history of speech and language delay. Maternal age at delivery, family income, education level and number of older siblings were also assessed. When the participating children were 5–6 years old, stimulation of the child at home was assessed by the psychologist using three subscales of the Home Observation for the Measurement of the Environment Scale: language stimulation, academic stimulation, and variety of experimentations (Caldwell & Bradley, 1984; Frankenburg & Coons, 1986). Higher scores represent greater cognitive stimulation and emotional support.

2.3. Data analysis

First, logistic regression analyses were used to compare predictors of cognitive development in disabled (FSIQ < 70, Group 1) and gifted (FSIQ > 130, Group 3) children as compared to those with a FSIQ ≥ 70 and ≤ 130 (Group 2). Then, logistic regression analyses were performed to compare SDQ scores at 5–6 years in Group 1 and Group 3 to Group 2 (unadjusted models; because the number of subjects in each group was not sufficient to adjust for relevant predictors). To avoid including associations that could be significant due to multiple testing, we evaluated statistical significance using a two-sided design with alpha set at .01, corresponding to a Bonferroni correction for the 5 scales of the SDQ.

Comparisons of emotional, behavioral and social difficulties between Group 1 and Group 2 were conducted to determine whether our study had sufficient power to detect differences at the opposite extreme of IQ distribution.

We tested the most common definition of giftedness (FSIQ > 130) and broader ones (FSIQ > 120, FSIQ > 125; verbal or performance IQ > 130) and a narrower one (FSIQ > 135). Logistic regression analyses were performed to compare SDQ scores at 5–6 years in these groups to children with normal FSIQ (unadjusted models and models adjusted for relevant predictors when the number of subjects in each group was sufficient).

Finally, in order to reduce bias due to confounding and given our small sample of gifted children, children with FSIQ in the normal range were matched with gifted children on several predictors of cognitive development using Proc Survey Select in SAS. We randomly selected an unrestricted sample of 142 children with FSIQ in the normal range within 5 stratification variables (tobacco consumption during pregnancy, maternal depression after birth, parental education, family stimulation at 5–6 years and recruitment center) to render this group comparable with gifted children. Logistic regression analyses were performed to compare SDQ scores at 5–6 years in both groups.

3. Results

Supplementary Fig. 2 shows the distribution of FSIQ scores in the EDEN mother–child cohort (N = 1100; mean = 103.0; standard deviation = 13.6). We identified 19 children (1.7%) whose FSIQ was < 70, and 23 (2.1%) children whose FSIQ was > 130.

3.1. Early predictors

Table 1 shows predictors of cognitive development in Group 1 (n = 19), Group 2 (n = 1058) and Group 3 (n = 23). Gifted children (Group 3) had higher levels of parental education than those with IQ in the normal range (Group 2). There were more males in Group 1 (disabled) than in Group 2 (79% vs 53%), while Groups 2 and 3 (48%) had a similar sex ratio. Moreover, children in Group 1 had lower levels of parental income and lower gestational age than those in Group 2.

3.2. Strengths & Difficulties Questionnaires (SDQ)

We did not find significant differences in behavioral, emotional and social problems at 5–6 years when comparing Groups 3 and 2 (unadjusted models; see Table 2). The emotional symptoms score reached a marginal p-value (unadjusted model: Cohen's d = .43, p = .045) for the comparison between groups 2 and 3. In order to test how robust potential differences in emotional symptoms scores might be, we assessed the extent to which they were sensitive to different thresholds and different definitions of giftedness. We thus compared SDQ scores between Groups 2 and 3 using more inclusive definitions of giftedness: FSIQ > 120 [N = 93], FSIQ > 125 [N = 42] and verbal or performance IQ > 130 [N = 53] (Supplementary Tables 1, 2 and 3). We did not find any significant differences in behavioral, emotional (all p-values > .2) and social problems in both unadjusted and adjusted models. Examining a more stringent threshold, we did not find any significant differences in behavioral, emotional and social problems between children with FSIQ > 135 and children with FSIQ within 70 and 135 in unadjusted models (Supplementary Table 4). Overall these sensitivity analyses do not lend support to the hypothesis that gifted children score consistently higher in emotional symptoms than normal IQ children. We also did not find significant differences in behavioral, emotional and social problems at 5–6 years when comparing Group 3 and a selection of Group 2 children matched closely with Group 3 on several predictors of cognitive development (Supplementary Tables 5 and 6). Supplementary Fig. 1 depicts the distribution of the SDQ emotional symptoms score according to FSIQ scores (categorized into 40 groups). Although children with FSIQ scores above 130 do seem to score a bit higher than those with normal IQ, there seems to be no continuity with the next group of children with scores between 120 and 130 (considered as gifted children in some studies).

Finally, when comparing Group 1 with Group 2, we found that children with FSIQ below 70 had significantly higher hyperactivity/inattention symptoms score at 5–6 years (unadjusted models) (Table 2).

3.3. Post hoc analysis

To further investigate the possible effect of high-IQ on emotional difficulties, we performed an item-wise comparison between Group 2 (70 ≤ FSIQ ≤ 130) and Group 3 (FSIQ > 130). We found that one specific item, "many worries or often seems worried" was significantly more frequent in Group 3 (in the unadjusted model: p = .009; adjusted model: p = .011; see Table 2), whereas other items gave similar results in both groups. This specific item could explain the marginally

Table 1
Summary statistics of the participating children.

	Group 1	Group 2	Group 3	1 vs 2	2 vs 3
	IQ < 70	70 ≤ IQ ≤ 130	IQ > 130	p-value	p-value
	n = 19	n = 1058	n = 23		
Male gender, %	79.0	52.8	47.8	**0.028**	0.600
Alcohol during pregnancy (drinks/week)	0.9 (1.5)	0.6 (1.4)	0.5 (1.0)	0.435	0.748
Tobacco consumption during pregnancy, %	16.7	22.7	4.4	0.305	0.071
Score for family stimulation at 5–6 years	16.6 (3.1)	17.3 (2.3)	17.7 (1.9)	0.365	0.355
Ever breastfed, %	63.2	72.8	87.0	0.641	0.146
Any breastfeeding duration (months)	3.4 (4.4)	3.3 (3.7)	3.3 (2.9)	0.453	0.995
Maternal depression during pregnancy, %	33.3	22.4	21.7	0.214	0.943
Maternal depression after birth, %	31.6	32.9	47.8	0.757	0.141
Parental education (years)	12.3 (2.2)	13.5 (2.3)	14.6 (2.1)	0.070	**0.027**
Household income (k€)	2.2 (1.0)	2.7 (1.0)	3.1 (0.8)	**0.048**	0.097
Maternal age at birth of child (years)	28.8 (4.7)	29.7 (4.8)	29.3 (4.8)	0.591	0.705
Number of older siblings	0.6 (0.7)	0.8 (0.9)	0.5 (0.8)	0.505	0.106
Gestational age (weeks)	38.4 (2.1)	39.3 (1.7)	39.3 (2.5)	**0.036**	0.932
Birth weight (kg)	3.2 (0.7)	3.3 (0.5)	3.3 (0.5)	0.837	0.985
Recruitment center (Nancy)	21.1	41.4	82.6	0.056	<**0.001**
IQ scores at 5–6 years					
Full scale IQ	59.7 (9.1)	103.1 (11.6)	134.6 (3.1)	<**0.001**	<**0.001**
Verbal IQ	70.6 (12.7)	106.7 (12.9)	132.7 (8.3)	<**0.001**	<**0.001**
Performance IQ	62.7 (10.3)	99.3 (12.4)	128.1 (9.2)	<**0.001**	<**0.001**

In bold p-values <0.05 (Wald test).

significant difference in emotional symptoms observed at 5–6 years between Groups 2 and 3.

4. Discussion

Using data from the EDEN prospective mother–child cohort, we used the Strength and Difficulties questionnaire (SDQ) to examine emotional, behavioral and social skills in a sample of gifted children aged 5–6 years. Contrary to previous claims of a possible excess in social, behavioral and emotional difficulties in gifted children (Blaas, 2014; Guénolé et al., 2013; Harrison & Haneghan, 2011), we found no such association, at least at this age. However a marginally significant association ($p = 0.045$ uncorrected) between high-IQ (FSIQ >130) and emotional difficulties was found. We performed several supplementary analyses to further explore this association:

(1) We found no such association when using different definitions of giftedness (FSIQ >120; FSIQ >125; verbal or performance IQ > 130; FSIQ >135). An excess of emotional difficulties was observed only starting from 130, suggesting that emotional difficulties could be observed only above a relatively high IQ threshold. However, when comparing children with FSIQ >135 and children with FSIQ ranging between 70 and 135, we again did not find significant differences in emotional problems (Supplementary Table 4). Thus, the marginally significant association found with an FSIQ threshold of 130 seems to be extremely sensitive to this particular definition and threshold. These results suggest that this apparent association is more likely to be a chance finding due to a few subjects with particular characteristics than to reveal a robust association between high IQ and emotional symptoms. Obviously, only larger population-based studies with an even higher number of children in the high IQ range will be able to definitively settle this question.

(2) This marginally significant association was apparently due to the single item: “many worries or often seems worried”. One previous study found a positive association between worry and intelligence in a non-clinical sample of young adults (Penney, Miedema, & Mazmanian, 2015) using the Penn State Worry Questionnaire. No study has, to our knowledge, replicated this result in a sample of preschool children. Thus, if the association between giftedness and emotional difficulties in the preschool period turns out to be robust, it is likely to be in fact a specific association between giftedness and a tendency to worry.

Table 2
Comparison of the SDQ scores at 5–6 years between Groups 1 (FSIQ <70) and 3 (FSIQ >130) and Group 2 (70 ≤ IQ ≤ 130).

				Unadjusted models	Unadjusted models
	Group 1	Group 2	Group 3	1 vs 2	2 vs 3
	IQ < 70	70 ≤ IQ ≤ 130	IQ > 130	Wald Test	Wald Test
	n = 19	n = 1058	n = 23	p-value	p-value
SDQ Dimensions at 5–6 years					
Emotional symptoms score at 5–6 years	7.5 (2.2)	7.1 (1.9)	7.9 (1.7)	0.531	0.045
Often complains of headaches, stomach-aches or sickness	1.4 (0.5)	1.4 (0.6)	1.4 (0.5)	0.804	0.869
Many worries or often seems worried	1.7 (0.8)	1.5 (0.7)	1.9 (0.7)	0.496	**0.009**
Often unhappy, depressed or tearful	1.1 (0.3)	1.2 (0.4)	1.2 (0.4)	0.624	0.898
Nervous or clingy in new situations, easily loses confidence	1.8 (0.8)	1.5 (0.7)	1.8 (0.7)	0.864	0.063
Many fears, easily scared	1.5 (0.7)	1.5 (0.6)	1.7 (0.6)	0.433	0.140
Conduct problems score at 5–6 years	6.2 (2.0)	5.4 (2.1)	5.1 (2.5)	0.143	0.570
Hyperactivity/inattention symptoms score at 5–6 years	6.4 (2.5)	4.1 (2.4)	3.3 (2.6)	**0.003**	0.139
Peer relationship problems score at 5–6 years	2.9 (1.6)	2.2 (1.3)	2.3 (1.8)	0.298	0.691
Prosocial behavior score at 5–6 years	13.4 (1.5)	13.3 (1.7)	13.6 (1.5)	0.747	0.530

In bold p-values <0.01 (Wald test).

Overall, the general claim that gifted children suffer from a range of emotional and conduct difficulties is not supported by our data (nor is the opposite idea that they might be less prone to emotional and conduct difficulties than children with average intelligence), although it may be the case that children with high-IQ manifest more worries during the preschool period. As mentioned by Martins (Martin et al., 2010), previous studies conducted on gifted children may have been biased towards those who had higher social, behavioral and emotional difficulties because these children were recruited through clinical psychologists or even in psychiatry departments (e.g. Louis et al., 2003) or in special education schools (e.g. Shechtman & Silektor, 2012). The fact that some clinicians have the impression that gifted children have more emotional problems is most probably due to the obvious sampling biases inherent to clinical practice.

These conclusions must of course be moderated by the limitations of the present study.

First, they are limited to the age range investigated. Although we do not find much evidence for emotional, behavioral or social difficulties in high-IQ children at 5–6 years of age, this does not preclude the possibility that such difficulties might appear later. The preschool period is only the first major change experienced by children, bringing new challenges in terms of social skills, as well as emotional and behavioral regulation. Maybe it is only upon entering primary school and experiencing a much more formal teaching environment that some gifted children feel less well-adjusted. Some authors even suggest that it is only around adolescence that gifted children tend to experience difficulties (Jackson & Peterson, 2003). These hypotheses can only be tested in populations of older children.

Second, the group of gifted children (FISQ above 130) in the present study is relatively modest ($n = 23$). Our study had 43% power to detect a difference of 1.1 points in SDQ emotional difficulties (Cohen's $d = .50$) between Group 2 and Group 3, with a significance level of 0.01. Consequently, our study may have lacked power to detect moderate associations between IQ and emotional, behavioral and social difficulties. This limitation could only be lifted by studies relying on larger population-based samples. Indeed, as explained in the Introduction, pre-selection approaches aiming to "enrich" the population with gifted children face excessively high risks of sampling bias, making it impossible to properly answer the question of interest.

Third, the instrument used to assess children's emotional, behavioral and social difficulties (the SDQ) has limitations. This is a parental questionnaire, with only 5 questions per scale, and each question is rated 0, 1, or 2. This may limit the range of responses, artificially making children in different groups seem more similar than they truly are. We also noted that the peer relationship problems scale had a low internal consistency (< 0.60). It is possible that instruments based on a higher number of questions, with questions gathered from several informants, or based on direct observations might be more sensitive to the problems experienced by gifted children, if these are too subtle to be captured by the SDQ questions.

Fourth, there was evidence for some selection bias due to missing data; indeed, children whose neuropsychological data were available at 5–6 years had higher parental educational level and family income than children with missing data. As these variables are known to be associated with emotional, behavioral and social difficulties, such a bias reduces the variance of our sample and therefore the statistical power of our analysis.

4.1. Perspectives

It will be of great interest to address the question whether high-IQ children show increased symptoms of emotional, behavioral and social difficulties in a larger population-based sample of preschool children (that would also include a greater number of high IQ children). Similar studies are also needed on populations of older children, to determine whether emotional, behavioral and social difficulties may manifest later during childhood and adolescence.

4.2. Conclusion

In conclusion, the data from the EDEN mother–child cohort do not support the hypothesis that 5–6 year-old children with high IQ experience more emotional, behavioral and social difficulties than children with normal IQ. If they do, then these difficulties must be very subtle and therefore went undetected in the present study. We found some evidence suggesting that gifted children may have a tendency to worry excessively, a result that would need to be replicated.

Authors' contributions

The EDEN mother–child cohort study group designed the entire project and collected the data. HP, FR and NG designed the specific research question; all authors analyzed the data and wrote the paper.

Funding

The EDEN study was supported by: Foundation for medical research (FRM), National Agency for Research (ANR), National Institute for Research in Public health (IRESP: TGIR cohorte santé 2008 program), French Ministry of Health (DGS), French Ministry of Research, INSERM Bone and Joint Diseases National Research (PRO-A) and Human Nutrition National Research Programs, Paris–Sud University, Nestlé, French National Institute for Population Health Surveillance (InVS), French National Institute for Health Education (INPES), the European Union FP7 programs (FP7/2007-2013, HELIX, ESCAPE, ENRIECO,Medall projects), Diabetes National Research Program (through a collaboration with the French Association of Diabetic Patients (AFD)), French Agency for Environmental Health Safety (now ANSES), Mutuelle Générale de l'Education Nationale a complementary health insurance (MGEN), French national agency for food security, French speaking association for the study of diabetes and metabolism (ALFEDIAM). Additional funding came from ANR contracts ANR-10-LABX-0087 IEC, ANR-11-0001-02 PSL*, and ANR-12-DSSA-0005-01.

Acknowledgements

- We are grateful to the participating families, the midwife research assistants (L Douhaud, S Bedel, B Lortholary, S Gabriel, M Rogeon, and M Malinbaum) for data collection, the psychologists (Marie-Claire Cona and Marielle Paquinet) and P Lavoine, J Sahuquillo and G Debotte for checking, coding, and data entry.

- Members of the EDEN mother-child cohort study group are as follows: I. Annesi-Maesano, J.Y. Bernard, J. Botton, M.A. Charles, P. Dargent-Molina, B. de Lauzon-Guillain, P. Ducimetière, M. de Agostini, B. Foliguet, A. Forhan, X. Fritel, A. Germa, V. Goua, R. Hankard, B. Heude, M. Kaminski, B. Larroque†, N. Lelong, J. Lepeule, G. Magnin, L. Marchand, C. Nabet, F. Pierre, R. Slama, M.J. Saurel-Cubizolles, M. Schweitzer, O. Thiebaugeorges

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.paid.2016.02.014.

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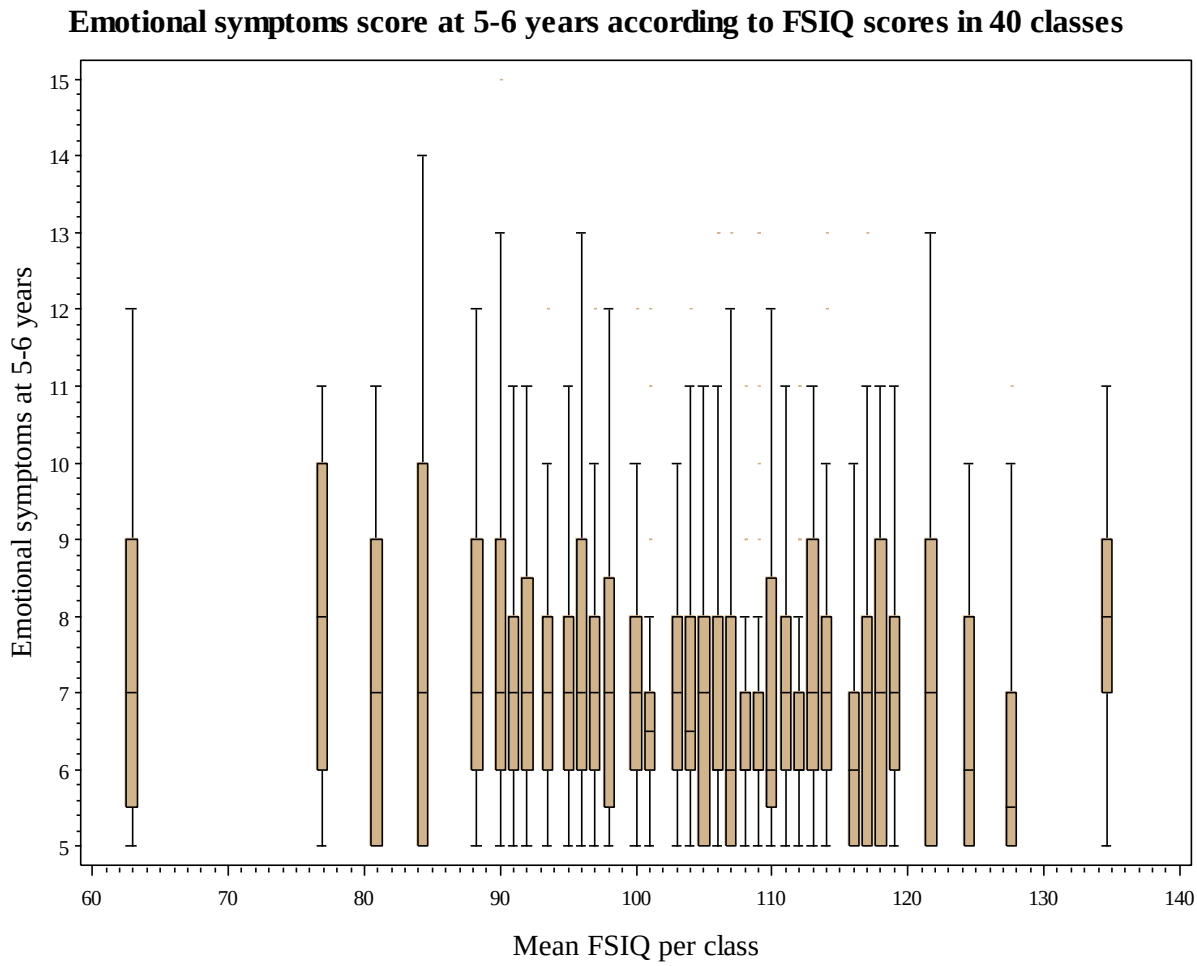
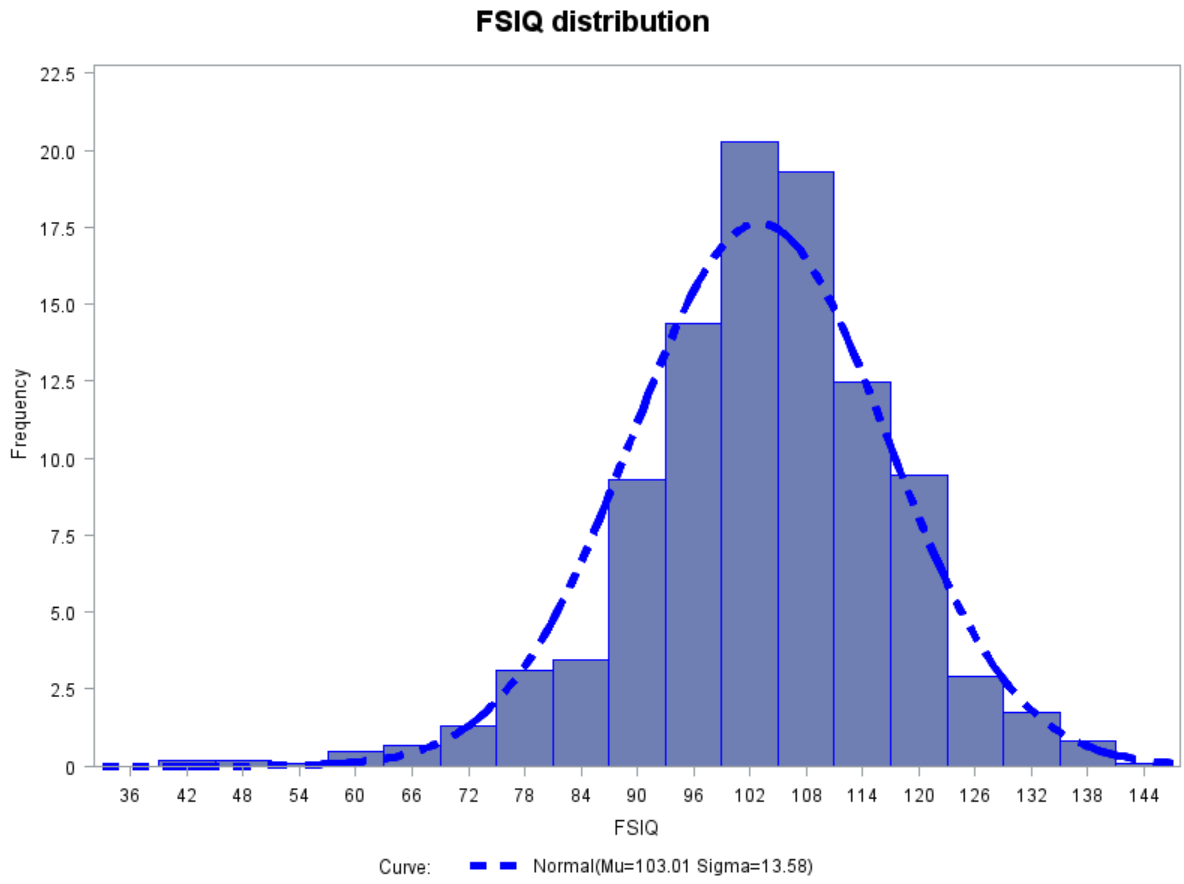
Supplementary Figure. Emotional symptoms score at 5-6 years according to FSIQ score in 40 classes.



Notes: For the boxplot, FSIQ scores were categorized into 40 groups of similar sizes ordered by percentiles, to ensure that the top box included exactly the 23 children identified as gifted.

Supplementary Figure 2. Distribution of FSIQ scores at 5-6 years in the EDEN mother-child cohort (N = 1100; mean = 103.0; standard deviation = 13.6).



Supplementary Table 1 . Comparison of the SDQ scores at 5-6 years between Groups 1 (FSIQ < 70) and 3 (FSIQ > 120) and Group 2 (70 ≤ IQ ≤ 120).

	Group 1 IQ < 70 n = 19	**Group 2 70 ≤ IQ ≤ 120 n = 988**	**Group 3 IQ > 120 n = 93**	Unadjusted models **1 *vs* 2 Wald Test p-value**	Unadjusted models **2 *vs* 3 Wald Test p-value**	Adjusted models **2 *vs* 3 Wald Test p-value**
SDQ Dimensions at 5-6 years						
Emotional symptoms score at 5-6 years	7.5 (2.2)	7.1 (1.9)	7.2 (2.0)	0.377	0.834	0.688
Conduct problems score at 5-6 years	6.2 (2.0)	5.4 (2.1)	5.2 (2.1)	0.096	0.513	0.962
Hyperactivity/inattention symptoms score at 5-6 years	6.4 (2.5)	4.1 (2.4)	3.5 (2.3)	**<0.001**	0.016	0.331
Peer relationship problems score at 5-6 years	2.9 (1.6)	2.2 (1.3)	2.2 (1.5)	0.036	0.699	0.228
Prosocial behavior score at 5-6 years	13.4 (1.5)	13.4 (1.7)	13.3 (1.8)	0.886	0.699	0.399

In bold p-values < 0.01 (Wald test).

Adjusted for tobacco consumption during pregnancy, parental education, household income and recruitment center.

Supplementary Table 2 . Comparison of the SDQ scores at 5-6 years between Groups 1 (FSIQ < 70) and 3 (FSIQ > 125) and Group 2 (70 ≤ IQ ≤ 125).

	Group 1 IQ < 70 n = 19	**Group 2 70 ≤ IQ ≤ 125 n = 1039**	**Group 3 IQ > 125 n = 42**	Unadjusted models **1 *vs* 2 Wald Test p-value**	Unadjusted models **2 *vs* 3 Wald Test p-value**	Adjusted models **2 *vs* 3 Wald Test p-value**
SDQ Dimensions at 5-6 years						
Emotional symptoms score at 5-6 years	7.5 (2.2)	7.1 (1.9)	7.3 (1.9)	0.377	0.626	0.499
Conduct problems score at 5-6 years	6.2 (2.0)	5.4 (2.1)	5.1 (2.2)	0.096	0.385	0.555
Hyperactivity/inattention symptoms score at 5-6 years	6.4 (2.5)	4.1 (2.4)	3.2 (2.4)	**<0.001**	0.020	0.092
Peer relationship problems score at 5-6 years	2.9 (1.6)	2.2 (1.3)	2.2 (1.7)	0.037	0.904	0.632
Prosocial behavior score at 5-6 years	13.4 (1.5)	13.3 (1.7)	13.6 (1.7)	0.851	0.266	0.450

In bold p-values < 0.01 (Wald test).

Adjusted for tobacco consumption during pregnancy, parental education, household income and recruitment center.

Supplementary Table 3 . Comparison of the SDQ scores at 5-6 years between Groups 1 (FSIQ < 70) and 3 (Verbal or performance IQ > 130) and Group 2.

	Group 1 **IQ < 70** **n = 19**	**Group 2** **70 ≤ IQ and verbal and performance IQ ≤ 130** **n = 1028**	**Group 3** **Verbal or performance IQ > 130** **n = 53**	Unadjusted models **1 *vs* 2** **Wald Test p-value**	Unadjusted models **2 *vs* 3** **Wald Test p-value**	Adjusted models **2 *vs* 3** **Wald Test p-value**
SDQ Dimensions at 5-6 years						
Emotional symptoms score at 5-6 years	7.5 (2.2)	7.1 (1.9)	7.3 (2.1)	0.371	0.490	0.261
Conduct problems score at 5-6 years	6.2 (2.0)	5.4 (2.1)	5.2 (2.2)	0.095	0.550	0.953
Hyperactivity/inattention symptoms score at 5-6 years	6.4 (2.5)	4.1 (2.4)	3.5 (2.5)	**<0.001**	0.095	0.863
Peer relationship problems score at 5-6 years	2.9 (1.6)	2.2 (1.3)	2.2 (1.4)	0.039	0.856	0.338
Prosocial behavior score at 5-6 years	13.4 (1.5)	13.4 (1.7)	13.5 (1.7)	0.855	0.421	0.634

In bold p-values < 0.01 (Wald test).

Adjusted for tobacco consumption during pregnancy, parental education, household income and recruitment center.

Supplementary Table 4 . Comparison of the SDQ scores at 5-6 years between Groups 1 (FSIQ < 70) and 3 (FSIQ > 135) and Group 2 (70 ≤ IQ ≤ 135).

	Group 1 IQ < 70 n = 19	**Group 2 70 ≤ IQ and ≤ 135 n = 1074**	**Group 3 IQ > 135 n = 7**	Unadjusted models **1 *vs* 2 Wald Test p-value**	Unadjusted models **2 *vs* 3 Wald Test p-value**
SDQ Dimensions at 5-6 years					
Emotional symptoms score at 5-6 years	7.5 (2.2)	7.1 (1.9)	7.3 (1.0)	0.383	0.671
Conduct problems score at 5-6 years	6.2 (2.0)	5.4 (2.1)	5.7 (2.4)	0.091	0.662
Hyperactivity/inattention symptoms score at 5-6 years	6.4 (2.5)	4.1 (2.4)	2.6 (2.1)	**<0.001**	0.105
Peer relationship problems score at 5-6 years	2.9 (1.6)	2.2 (1.3)	2.6 (2.2)	0.038	0.456
Prosocial behavior score at 5-6 years	13.4 (1.5)	13.3 (1.7)	13.1 (1.6)	0.877	0.747

In bold p-values < 0.01 (Wald test).

Supplementary Table 5 . Summary statistics of children with Full Scale IQ > 130 (Group 3) and those in the normal range (70 ≤ IQ ≤ 130) matched with Group 3 on several predictors of cognitive development.

	Group 2 matched with Group 3 70 ≤ IQ ≤ 130 n = 142	Group 3 IQ > 130 n = 23	2 *vs* 3 p-value
Male gender, %	43.7	47.8	0.692
Alcohol during pregnancy (drinks/week)	0.4 (1.5)	0.5 (1.0)	0.793
Tobacco consumption during pregnancy, %	3.5	4.4	0.876
Score for family stimulation at 5-6 years	17.3 (2.4)	17.7 (1.9)	0.435
Breastfeeding, %	80.3	87.0	0.589
Breastfeeding duration (months)	3.8 (3.8)	3.3 (2.9)	0.512
Maternal depression during pregnancy, %	27.2	21.7	0.584
Maternal depression after birth, %	47.9	47.8	0.898
Parental education (years)	14.1 (2.2)	14.6 (2.1)	0.324
Household income (k€)	2.9 (0.9)	3.1 (0.8)	0.382
Maternal age at birth of child (years)	30.2 (4.6)	29.3 (4.8)	0.410
Number of older siblings	0.9 (1.0)	0.5 (0.8)	0.078
Gestational age (weeks)	39.2 (1.7)	39.3 (2.5)	0.855
Birth weight (kg)	3.3 (0.5)	3.3 (0.5)	0.987
Recruitment center (Nancy)	82.4	82.6	0.976
IQ scores at 5-6 years			
Full scale IQ	105.1 (11.4)	134.6 (3.1)	**<0.001**
Verbal IQ	109.2 (13.5)	132.7 (8.3)	**<0.001**
Performance IQ	100.9 (11.0)	128.1 (9.2)	**<0.001**

In bold p-values < 0.05 (Wald test).

Supplementary Table 6. Comparison of the SDQ scores at 5-6 years between children with Full Scale IQ > 130 (Group 3) and those in the normal range (70 ≤ IQ ≤ 130) matched with Group 3 on several predictors of cognitive development.

	Group 2 matched with Group 3 **70 ≤ IQ ≤ 130** **n = 210**	**Group 3** **IQ > 130** **n = 23**	Unadjusted models ***2 vs* 3** **Wald Test p-value**
SDQ Dimensions at 5-6 years			
Emotional symptoms score at 5-6 years	7.1 (2.0)	7.9 (1.7)	0.059
Conduct problems score at 5-6 years	5.3 (2.1)	5.1 (2.5)	0.807
Hyperactivity/inattention symptoms score at 5-6 years	3.7 (2.1)	3.3 (2.6)	0.437
Peer relationship problems score at 5-6 years	2.1 (1.3)	2.3 (1.8)	0.593
Prosocial behavior score at 5-6 years	13.4 (1.7)	13.6 (1.5)	0.617

Supplementary Table 7. Correlation between the SDQ scores at 5-6 years and Full Scale IQ, verbal IQ and Performance IQ (N=1100).

	IQ scores at 5-6 years		
	Full scale IQ	Verbal IQ	Performance IQ
SDQ Dimensions at 5-6 years			
Emotional symptoms score at 5-6 years	-0.06	0.04	-0.07*
Conduct problems score at 5-6 years	-0.14***	-0.12***	-0.11***
Hyperactivity/inattention symptoms score at 5-6 years	-0.27***	-0.24***	-0.22***
Peer relationship problems score at 5-6 years	-0.11***	-0.11***	-0.07*
Prosocial behavior score at 5-6 years	0.10**	0.11***	0.05

*p-values < 0.05. **p-values < 0.01.***p-values < 0.001.