Implications of Extending the ADHD Age-of-Onset Criterion to Age 12: Results from a Prospectively Studied Birth Cohort

Guilherme Polanczyk, M.D., Ph.D., Avshalom Caspi, Ph.D., Renate Houts, Ph.D., Scott H. Kollins, Ph.D., Luis Augusto Rohde, M.D., Ph.D., Terrie E. Moffitt Ph.D.

Objective: To evaluate whether including children with onset of symptoms between ages 7 and 12 years in the ADHD diagnostic category would: (a) increase the prevalence of the disorder at age 12, and (b) change the clinical and cognitive features, impairment profile, and risk factors for ADHD compared with findings in the literature based on the DSM-IV definition of the disorder. **Method:** A birth cohort of 2,232 British children was prospectively evaluated at ages 7 and 12 years for ADHD using information from mothers and teachers. The prevalence of diagnosed ADHD at age 12 was evaluated with and without the inclusion of individuals who met DSM-IV age-of-onset criterion through mothers' or teachers' reports of symptoms at age 7. Children with onset of ADHD symptoms before versus after age 7 were compared on their clinical and cognitive features, impairment profile, and risk factors for ADHD. **Results:** Extending the age-of-onset criterion to age 12 resulted in a negligible increase in ADHD prevalence by age 12 years of 0.1%. Children who first manifested ADHD symptoms between ages 7 and 12 did not present correlates or risk factors that were significantly different from children who manifested symptoms before age 7. **Conclusions:** Results from this prospective birth cohort might suggest that adults who are able to report symptom onset by age 12 also had symptoms by age 7, even if they are not able to report them. The data suggest that the prevalence estimate, correlates and risk factors of ADHD will not be affected if the new diagnostic scheme extends the age-of-onset criterion to age 12. J. Am. Acad. Child Adolesc. Psychiatry, 2010;49(3):210–216. **Key Words:** ADHD, Attention-deficit/hyperactivity disorder, Diagnostic criteria, DSM-IV, DSM-V, Age-of-onset.

As the DSM-V is under development, it is critical to generate empirical evidence to support the revision of current diagnostic criteria.[1] With regard to attention-deficit/hyperactivity disorder (ADHD), the scientific community has called for revising the current age-of-onset criterion (i.e., the current requirement that symptoms associated with impairment must be present before age 7 years)[2-4] by extending the upper limit to age 12 years.[5,6] However, the implications of this proposal have not been evaluated in a prospective longitudinal study. In this article, we aimed to investigate whether extending the upper limit of age-of-onset of symptoms from age 7 to age 12 would (a) increase the prevalence of the disorder[7] and (b) change the clinical and cognitive features, impairment profile, and risk factors for ADHD, compared with what has accumulated in the literature using the DSM-IV definition of the disorder.

As a developmental disorder, ADHD is likely to be first recognized during childhood and may persist throughout the life span.[8] To avoid misdiagnosing children who exhibit inattention, hyperactivity, or impulsivity as a reaction to school stress,[2,9] DSM-III and DSM-III-R required the presence of symptoms before age 7. In DSM-IV, this criterion was modified to require the presence of symptoms that cause impairment before age 7. However, there was no empirical evidence to support this modification, which is difficult to assess in clinical settings.[2,3,10] In fact, a report from the DSM-IV field trials indicated that retro-

This article is discussed by Dr. Russell A. Barkley in an editorial on page 205.

spectively reported age-of-onset of impairing symptoms reduced the accuracy of the identification of cases currently impaired.[9] This is probably because symptom impairment depends upon several factors, such as the perception and definition of impairment by the informant, the availability of support from parents and/or schools that may prevent noticeable impairment, variations in demands and expectations placed on children, number of life domains that an individual is exposed to, as well as the symptom picture itself (inattentive symptoms tend to cause impairment later in life more so than hyperactive symptoms).[2,5,10] The DSM-IV field trial also indicated that concerns about the validity of this criterion should increase as the period of time that must be recalled by parents increases.[9]

As ADHD became recognized in older adolescents and adults, concerns grew about whether individuals themselves (or their parents) could provide accurate retrospective reports about the occurrence of symptoms producing impairment in the first 6 years of life.[6] In fact, two findings have challenged the validity of the age-of-onset criterion. First, a longitudinal study with retrospective reports of age-of-onset at all evaluations showed that out of those children who met full diagnostic criteria for ADHD at the first evaluation and who continued to meet all other criteria for ADHD 5 years later, approximately 50% failed to meet the age-of-onset criterion at the follow-up.[4] Second, a comparison of adults with late-onset ADHD (predominantly with age-of-onset between ages 7 to 12) to those with early onset ADHD (before age 7) revealed a similar pattern of comorbidity, functional impairment, neuropsychological dysfunction, and family history.[11] Based on these results, it has been proposed that extending the age-of-onset criterion to age 12 would reduce the period that individuals are required to recollect, and would also transfer the focus of memory to middle childhood, which would potentially increase the validity of retrospective reports.[5,6]

To address the validity of extending the age-of-onset criterion to age 12 years, two methodological strategies are needed. First, it is necessary to focus on the onset of symptoms, rather than onset of impairment. There is no empirical evidence to indicate that evaluating onset of impairment yields greater predictive validity than evaluating the onset of symptoms[2]; in fact, it may be less reliable.[2,9,10] Second, it is necessary to evaluate prospective longitudinal data. In a prospective longitudinal study, it is possible to evaluate children at specific ages of interest; therefore, it is not necessary to rely on the memories of their parents (except to specify the occurrence of symptoms in the preceding 6 months, as defined in the diagnostic criteria). In addition, multisource longitudinal studies contain information from teachers, which is important, considering that the manifestation of symptoms may vary according to setting.[12] It is impractical to gather such multisource data in retrospective studies, because different teachers interact with the child at different ages, usually for a limited period of time.

Based on this background, we analyzed data collected in the Environmental Risk (E-Risk) Longitudinal Study, which tracks a nationally representative sample of children. The children were prospectively evaluated for ADHD during childhood using DSM-IV criteria. Our aims were to test the implications of extending the ADHD age-of-onset criterion from age 7 to 12. If it is the presence of full ADHD diagnostic criteria that identifies a true case of ADHD, we hypothesized that modifying the age-of-onset criterion would not result in a significant increase in the prevalence of the disorder. Moreover, we hypothesized that if age 12 years, as previously suggested[5,6,13] based on empirical findings,[11] is a legitimate developmental limit up to when primary inattention and/or hyperactivity must have been manifest, then children with age-of-onset of symptoms before age 7 and children with onset between ages 7 to 12 should present with similar correlates of and risk factors for ADHD.

METHOD

Participants

Participants were members of the E-Risk Study, which tracks the development of a birth cohort of 2,232 British children. The sample was drawn from a larger birth register of twins born in England and Wales in 1994 to 1995.[14] Details about the sample have been reported[15] and previously described in the *Journal*.[16] Briefly, a probability sampling strategy was used based on maternal age at first childbearing, yielding findings that can be generalized to the population of British families with children born in the 1990s. The E-risk sample was constructed in 1999 to 2000, when 1,116 families with same-sex, 5-year-old twins (93% of those eligible) participated in home-visit assessments. Questionnaires were obtained from the children's teachers. Subsequent follow-up home visits were con-

ducted and teachers' questionnaires were obtained when the children were aged 7 years (98% participation) and, most recently, 12 years (96% participation). Data were collected within 60 days of the child's birth. The Maudsley Hospital Ethics Committee approved each phase of the study.

ADHD Diagnosis

As previously described,[17,18] in the E-Risk Study, ADHD was ascertained on the basis of mother and teacher reports of all 18 symptoms according to DSM-IV. Symptoms were reported for the preceding 6 months. Symptom endorsement by teachers was based on their responses to a rating scale ("not true," "somewhat/sometimes," "very often true") of the 18 DSM-IV ADHD symptoms. We considered a symptom endorsed when teachers answered "very often true." For parental report, mothers were interviewed by a mental health trainee or professional and asked explicitly about each symptom. To be counted as an ADHD case, six or more inattentive and/or six or more hyperactivity–impulsivity symptoms must have been reported by either the mother or the teacher, and the other informant must have endorsed at least two symptoms, meeting the pervasiveness criterion across home and school. ADHD diagnosis was associated with at least one indicator of impairment investigated. More than 90% of diagnosed children presented three or more indicators of impairment.

Associated Characteristics Investigated

Demographic profile. Demographic profile was evaluated at age 5 years. Socio-economic status was defined by a composite of parental income, education, and occupation.[19]

Cognitive profile. Cognitive profile was evaluated at age 5. For IQ, the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) Revised was used.[20] Children were administered two subtests (Vocabulary and Block Design), and IQ scores were prorated following procedures described by Sattler.[21] To evaluate executive functioning, children were administered three executive functions tests: Mazes,[22] which is a WPPSI test; Day Night,[23] a nonverbal analogue of the Stroop task; and Sentence Working Memory, which is based on the Baddeley model of working memory[24,25] and requires the child to hold one (or more) item in active working memory while processing necessary information for the generation of the second item (and so forth). Children's scores on the three tests were averaged and standardized.

Clinical profile. Clinical profile was evaluated at age 12. Inattentive and hyperactive–impulsive symptoms were evaluated according to the DSM-IV criteria, maternal report. Depressive symptoms were assessed based on the Children's Depression Inventory,[26] children's report. Anxiety symptoms were assessed using the Multidimensional Anxiety Scale for Children,[27] children's report. Conduct symptoms were evaluated according to the DSM-IV criteria, children's report. Tobacco use or experimentation was assessed by a single item, children's report.

Impairment profile. Impairment profile was evaluated at age 12. Items included "Doesn't get along with other pupils," "Not liked by other pupils," "Disrupts class discipline," "Teacher must act frequently to curb disruptive behavior," "Teacher must act frequently to keep child's attention in class," single items, teacher report. Academic failure was based on performance in mathematics and English and teacher report. Parents' difficulty in monitoring the child was assessed according to the question, "Is it more difficult to monitor your child now that he/she is older?" on a single-item maternal report.

Exposure to perinatal risk factors. Exposure to perinatal risk factors was evaluated 1 year after birth. Multiple perinatal complications consisted of two or more of the following: high blood pressure, diabetes, preeclampsia, vaginal bleeding, water breaking more than 11 h before labor, slow baby growth, rubella during pregnancy, maternal report. Birth weight in relation to gestational age was assessed by absolute values for weight that were standardized with reference to birth weight in relation to gestational age of 19,000 twins born in England from 1988 to 1992.[28] Maternal smoking during pregnancy was based on maternal report, as previously described.[29]

Statistical Analysis

We conducted logistic and linear regression analyses to compare groups of children. Because each study family contains two children, statistical analyses were corrected conservatively for the nonindependence of the twin observations by using tests based on the sandwich or Huber/White variance estimator[30] with the command "cluster" in STATA version 10.[31]

RESULTS

Does Extending the Age-of-Onset Criterion from Age 7 to Age 12 Increase the Prevalence of ADHD at Age 12?

At age 12, a total of 66 children (3.3% of the sample, 95% CI = 2.5 to 4.1) met full diagnostic criteria for ADHD, which includes the age-of-onset criterion before age 7 years. A total of 181 children who had not presented with any ADHD symptom at age 7 years were reported either by their parents or teachers as presenting with one or more new-onset inattentive and/or hyperactive–impulsive symptoms at age 12. However, of these children, only two met full diagnostic cri-

teria for ADHD as defined by DSM-IV (except the age-of-onset criterion). Thus, extending the age-of-onset criterion to before age 12 would add two cases at age 12, increasing the prevalence estimate by 0.1%.

Do Children with Onset of Symptoms Between Ages 7 and 12 Differ from Those with Onset of Symptoms Before Age 7 years?

It was not possible to compare groups of children with ADHD at age 12 with onset of symptoms between ages 7 and 12 to children with ADHD with onset of symptoms before age 7, because there were only two children at age 12 who met full diagnostic criteria for ADHD and presented with symptoms for the first time between ages 7 and 12. Therefore, it was possible to test only whether, among children without ADHD, children with symptom onset between ages 7 and 12 years (n = 181) presented with profiles different from children with symptom onset before age 7 (n = 1,183) (Table 1). For contrast purposes, Table 1 also shows results for children with ADHD criteria at age 12 (n = 68) compared with children who never presented symptoms (n = 547).

Children with ADHD symptom onset between ages 7 and 12 versus children with symptom onset before age 7 differed on only four of 21 measures investigated; if correction for multiple testing were applied, the groups would differ on only one of 21 measures (Table 1). Specifically, children with symptom onset between ages 7 and 12 (a) performed slightly better on measures of executive functioning, (b) presented with fewer hyperactive–impulsive symptoms, (c) were more likely to disrupt class discipline, and (d) required more management of their attention from their teachers.

DISCUSSION

We prospectively assessed ADHD at ages 7 and 12 years in a birth cohort of children using both parents and teachers as informants and evaluated the impact and validity of extending the age-of-onset of symptoms from age 7 to age 12. Findings suggest that extending the age-of-onset to age 12 results in a negligible increase in ADHD prevalence by age 12 (0.1% in our cohort). In addition, non-ADHD children who first manifested new ADHD symptoms between ages 7 and 12 exhibited a profile of risk factors and correlates that was, in general, similar to that of children who manifested symptoms before age 7.

Our prospective assessments revealed that virtually all children who met full diagnostic criteria for ADHD at age 12 met the age-of-onset criterion before age 7. Community[32,33] and clinical[9-11] studies that rely on retrospective reports of age of onset detect that a significant proportion of adolescents and adults who meet full ADHD criteria recall their first symptoms as occurring after age 7. The virtual absence of children who had both full diagnostic criteria for ADHD at age 12 and first symptoms after age 7 in our cohort is most likely related to the strategies used to assess symptoms. First, symptoms were assessed prospectively, minimizing recall bias. Second, symptoms were assessed both at home and at school, according to the definition of ADHD as a pervasive disorder. Our results suggest that individuals with ADHD who have their first symptoms retrospectively reported between ages 7 and 12 are, in fact, likely to have also had symptoms before age 7.

Given the virtual nonexistence of cases with ADHD at age 12 who first presented with symptoms after age 7, we could not compare children with ADHD with symptom onset between ages 7 and 12 years to children with ADHD with symptom onset before age 7. Considering that ADHD has been documented to be dimensionally distributed in the population,[3] we evaluated whether non-ADHD children with ADHD symptom onset after age 7 presented with a distinct profile compared with children with symptom onset before age 7. All of the characteristics investigated were associated with ADHD diagnosis at age 12. The results showed that, independent of age of onset, groups of children with symptoms (but who did not meet ADHD diagnosis) presented with intermediate scores between those children who had never presented with any symptom and those with ADHD. In addition, the correlates and risk factors for ADHD did not differ consistently between the two groups of children with symptoms only. Results do not suggest that the first manifestation of symptoms before age 7 versus between ages 7 and 12 indexed distinct psychopathological processes. Therefore, the inclusion in future studies of children with onset of symptoms between ages 7 and 12 in the ADHD diagnostic category is not likely to alter what is already established about the correlates and risk factors for the disorder.

TABLE 1 Comparison Between Groups of Children According to ADHD Diagnosis at Age 12 and Age-of-Onset of Symptoms

Characteristic	Never Had Symptoms (n = 547)	Full ADHD Criteria[a] (n = 68)[b]	No ADHD			
			Symptoms Before Age 7 (n = 1,183)	Symptoms Between Ages 7 and 12 (n = 181)	Analysis[c]	
Demographic profile					**OR / B (SE)**	***p***
Male sex, N (%)	206 (38)	51 (75)	614 (52)	88 (49)	0.9 (0.15)	.448
White ethnicity, N (%)	487 (89)	67 (99)	1,068 (90)	163 (90)	1.0 (0.28)	.927
Low socioeconomic status, N (%)	108 (20)	36 (53)	435 (37)	65 (36)	1.0 (0.19)	.966
Cognitive profile						
IQ, mean (SD)[d]	104.9 (14.1)	89.7 (14.6)	98.7 (14.7)	100.4 (15.7)	1.6 (1.31)	.208
Executive functioning, mean (SD)[d]	102.2 (13.2)	93.5 (17.5)	99.3 (15.1)	102.0 (15.9)	2.7 (1.30)	.041
Clinical profile						
Inattentive symptoms, mean (SD)	0	5.4 (2.4)	.9 (1.7)	.9 (1.2)	−0.02 (0.11)	.855
Hyperactive-impulsive symptoms, mean (SD)	0	5.2 (2.8)	1.2 (1.9)	.8 (1.1)	−0.5 (0.10)	<.001
Depressive symptoms, mean (SD)[e]	−.18 (.68)	.75 (1.96)	.00 (.96)	.07 (1.02)	.07 (0.08)	.418
Anxiety symptoms, mean (SD)[e]	−.05 (.95)	.21 (1.14)	.00 (1.01)	.01 (.90)	.01 (0.07)	.889
Conduct symptoms, mean (SD)[e]	−.18 (.82)	.77 (1.32)	.02 (1.01)	.01 (1.02)	−.01 (0.08)	.888
Tobacco experimentation or use, N (%)	28 (5)	21 (32)	149 (13)	17 (10)	.72 (0.19)	.219
Impairment profile						
Does not get along with other pupils, N (%)	33 (7)	42 (64)	206 (20)	41 (24)	1.3 (0.27)	.154
Not liked by other pupils, N (%)	15 (3)	32 (49)	110 (11)	21 (13)	1.2 (0.32)	.393
Disrupts class discipline, N (%)	31 (7)	49 (75)	215 (21)	45 (27)	1.5 (0.29)	.050
Teacher has to act frequently to keep child's attention in class, N (%)	34 (8)	64 (99)	248 (24)	52 (31)	1.5 (0.28)	.042
Teacher has to act frequently to curb disruptive behavior, N (%)	20 (5)	47 (72)	178 (17)	33 (20)	1.2 (0.26)	.355
Academic failure, N (%)	55 (13)	49 (82)	274 (27)	40 (26)	0.9 (0.18)	.645
Parents with difficulties in monitoring the child, N (%)	14 (3)	29 (43)	165 (14)	22 (12)	0.9 (0.21)	.518
Exposure to perinatal adversities						
Multiple perinatal complications, N (%)	89 (19)	18 (35)	238 (24)	24 (18)	0.7 (0.17)	.116
Birth weight in relation to gestational age, mean (SD)	−0.003 (1.04)	−0.34 (1.02)	0.02 (1.01)	0.14 (1.06)	0.12 (0.09)	.176
Maternal smoking during pregnancy, N (%)	64 (12)	25 (44)	284 (26)	42 (26)	1.0 (0.2)	.921

Note: ADHD = attention-deficit/hyperactivity disorder; SD = standard deviation.

[a] *Only two children with full ADHD criteria presented with onset of symptoms after age 7.*

[b] *Pairwise comparisons between children with full ADHD criteria versus those who never had symptoms, except for anxiety symptoms, were all significant at p < .05.*

[c] *Pairwise comparisons between children with first symptoms between ages 7 and 12 versus those with first symptoms before age 7.*

[d] *Standardized values to mean = 100 and SD = 15.*

[e] *Standardized values to mean = 0 and SD = 1.*

Our study should be interpreted in the context of its limitations. First, our data cannot be used to estimate how many individuals first present with ADHD symptoms after age 12, as that is the oldest age that we studied here. Second, our results do not refer to the age of onset of impairing symptoms, as currently defined by DSM-IV, but rather to the age of onset of symptoms. However, this is consistent with the following: (a) evidence indicating the reduced clinical utility of age-of-onset of impairment[10]; (b) DSM-III, DSM-III-R, and ICD-10 editions, which require age-of-onset of symptoms; and (c) with the DSM-V Task Force, which indicated the need for

"separating impairment and diagnostic assessments."[1] Third, we studied a cohort of twins, who may not represent singletons. However, prior comparisons have found no twin–singleton differences in behavior problems (including ADHD symptoms), IQ, or personality traits.[34-39] Nevertheless, replication of findings in studies of singletons is important.

Our results suggest that there are virtually no children with diagnosable ADHD at age 12 whose symptoms first appeared after age 7. Considering that the age-of-onset criterion is assessed retrospectively in clinical settings, individuals who meet full ADHD criteria and recall the onset of symptoms between ages 7 and 12 should have access to treatment, because the symptoms almost certainly emerged before age 7. The new diagnostic scheme for ADHD can safely extend the age-of-onset of symptoms to 12 years of age. &

Accepted December 21, 2009.

Drs. Polanczyk, Caspi, Houts, Kollins and Moffitt are with Duke University; Dr. Polanczyk is also with University of São Paulo Medical School & National Institute for Developmental Psychiatry, Brazil. Drs. Caspi and Moffitt are also with Social, Genetic, and Developmental Psychiatry Centre, Institute of Psychiatry, King's College London, England; Dr. Rohde is with Hospital de Clinicas de Porto Alegre, Federal University of Rio Grande do Sul, Brazil.

This research was supported by the UK Medical Research Council (G9806489, G0100527, and G0601483).

We thank the families and staff of the E-risk Study. We thank Lauren Bayer and Stephen Ross, who are with Duke University, for their assistance in preparing the manuscript.

Disclosure: Dr. Polanczyk has served as a speaker for Novartis and is a recipient of a 2008 National Alliance of Research on Schizophrenia and Depression (NARSAD) Young Investigator Award. Dr. Kollins has received research support and/or consultant fees from Addrenex Pharmaceuticals, Otsuka Pharmaceuticals, Shire Pharmaceuticals, the National Institute on Drug Abuse (NIDA), National Institute of Mental Health (NIMH), National Institute of Neurological Disorders and Stroke (NINDS), and Environmental Protection Agency (EPA). Dr. Rohde has served as a speaker and/or consultant for Eli Lilly, Janssen-Cilag, and Novartis in the last 3 years. Currently, his only industry-related activity is taking part in the advisory board/speakers' bureau for Eli Lilly and Novartis. The ADHD and Juvenile Bipolar Disorder Outpatient Programs chaired by him have received unrestricted educational and research support from the following pharmaceutical companies in the last 3 years: Abbott, Bristol-Myers Squibb, Eli Lilly, Janssen-Cilag, Novartis, and Shire. Dr. Houts, Caspi, and Moffitt report no biomedical financial interests or potential conflicts of interest.

Correspondence to: Dr. Polanczyk, Department of Psychiatry, University of São Paulo Medical School, Rua Dr. Ovidio Pires de Campos 785, 05453-010 São Paulo, SP–Brazil; e-mail: gvp.ez@terra.com.br

0890-8567/10/©2010 American Academy of Child and Adolescent Psychiatry

DOI: 10.1016/j.jaac.2009.12.014

REFERENCES

1. Regier DA, Narrow WE, Kuhl EA, Kupfer DJ. The conceptual development of DSM-V. Am J Psychiatry. 2009;166:645-650.
2. Barkley RA, Biederman J. Toward a broader definition of the age-of-onset criterion for attention-deficit hyperactivity disorder. J Am Acad Child Adolesc Psychiatry. 1997;36:1204-1210.
3. Rohde LA. Is there a need to reformulate attention deficit hyperactivity disorder criteria in future nosologic classifications? Child Adolesc Psychiatr Clin North Am. 2008;17:405-420.
4. Todd RD, Huang H, Henderson CA. Poor utility of the age of onset criterion for DSM-IV attention deficit/hyperactivity disorder: recommendations for DSM-V and ICD-11. J Child Psychol Psychiatry. 2008;49:942-949.
5. McGough JJ, Barkley RA. Diagnostic controversies in adult attention deficit hyperactivity disorder. Am J Psychiatry. 2004;161:1948-1956.
6. McGough JJ, McCracken JT. Adult attention deficit hyperactivity disorder: moving beyond DSM-IV. Am J Psychiatry. 2006;163:1673-1675.
7. Polanczyk G, de Lima MS, Horta BL, Biederman J, Rohde LA. The worldwide prevalence of ADHD: a systematic review and metaregression analysis. Am J Psychiatry. 2007;164:942-948.
8. Swanson JM, Sergeant JA, Taylor E, Sonuga-Barke EJ, Jensen PS, Cantwell DP. Attention-deficit hyperactivity disorder and hyperkinetic disorder. Lancet. 1998;351:429-433.
9. Applegate B, Lahey BB, Hart EL, *et al*. Validity of the age-of-onset criterion for ADHD: a report from the DSM-IV field trials. J Am Acad Child Adolesc Psychiatry. 1997;36:1211-1221.
10. Barkley RA, Murphy KR, Fischer M. DSM symptom utility and the issue of age of onset. In: Barkley RA, Murphy KR, Fischer M, eds. ADHD in Adults. *What the Science Says*. New York: Guilford Press; 2008:78-129.
11. Faraone SV, Biederman J, Spencer T, Mick E, Murray K, Petty C, Adamson JJ, Monuteaux MC. Diagnosing adult attention deficit hyperactivity disorder: are late onset and subthreshold diagnoses valid? Am J Psychiatry. 2006;163:1720-1729.
12. Sayal K, Goodman R. Do parental reports of child hyperkinetic disorder symptoms at school predict teacher ratings? Eur Child Adolesc Psychiatry. 2009;18:336-344.
13. Kieling C, Kieling RR, Rohde LA, *et al*. The age at onset of Attention Deficit Hyperactivity Disorder. *Am J Psychiatry*. 2010;167:14-16.
14. Trouton A, Spinath FM, Plomin R. Twins early development study (TEDS): a multivariate, longitudinal genetic investigation of language, cognition and behavior problems in childhood. Twin Res. 2002;5:444-448.
15. Moffitt TE. Teen-aged mothers in contemporary Britain. J Child Psychol Psychiatry. 2002;43:727-742.
16. Jaffee SR, Moffitt TE, Caspi A, Taylor A, Arseneault L. Influence of adult domestic violence on children's internalizing and externalizing problems: an environmentally informative twin study. J Am Acad Child Adolesc Psychiatry. 2002;41:1095-1103.
17. Caspi A, Langley K, Milne B, *et al*. A replicated molecular genetic basis for subtyping antisocial behavior in children with attention-deficit/hyperactivity disorder. Arch Gen Psychiatry. 2008;65:203-210.
18. Kuntsi J, Eley TC, Taylor A, *et al*. The co-occurrence of ADHD and low IQ has genetic origins. Am J Med Genet B Neuropsychiatr Genet. 2004;124B:41-47.
19. Trzesniewski KH, Moffitt TE, Caspi A, Taylor A, Maughan B. Revisiting the association between reading achievement and antisocial behavior: new evidence of an environmental explanation from a twin study. Child Dev. 2006;77:72-88.
20. Wechsler D. Weshler Preschool and Primary Scale of Intelligence–Revised. London: Psychological Corporation, Harcourt Brace; 1990.
21. Sattler J. *Assessment of Children: WISC-III and WPPSI-R Supplement*. San Diego: Jerome M. Sattler; 1992.
22. Grodzinsky GM, Diamond R. Frontal lobe functioning in boys with attention-deficit hyperactivity disorder. Dev Neuropsychol. 1992;8:427-445.

23. Gerstadt CL, Hong YJ, Diamond A. The relationship between cognition and action: performance of children 3 1/2-7 years old on a Stroop-like day-night test. Cognition. 1994;53:129-153.
24. Baddeley AD. Exploring the central executive. Q J Exp Psychol. 1996;49A:5-28.
25. Baddeley AD. *Working Memory.* Oxford: Clarendon Press; 1986.
26. Kovacs M. *Children's Depression Inventory (CDI) Manual.* Toronto, ON: Multi-Health Systems; 1992.
27. March JS, Parker JD, Sullivan K, Stallings P, Conners CK. The Multidimensional Anxiety Scale for Children (MASC): factor structure, reliability, and validity. J Am Acad Child Adolesc Psychiatry. 1997;36:554-565.
28. Buckler JM, Green M. Birth weight and head circumference standards for English twins. Arch Dis Child. 1994;71:516-521.
29. Maughan B, Taylor A, Caspi A, Moffitt TE. Prenatal smoking and early childhood conduct problems: testing genetic and environmental explanations of the association. Arch Gen Psychiatry. 2004;61:836-843.
30. Williams RL. A note on robust variance estimaton for cluster-correlated data. Biometrics. 2000;56:645-646.
31. STATA. *Version 9.0. Manuals.* College Station, TX: Stata Corporation; 2005.
32. Kessler RC, Berglund P, Demler O, Jin R, Merikangas KR, Walters EE. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. Arch Gen Psychiatry. 2005;62:593-602.
33. Rohde LA, Biederman J, Zimmermann H, Schmitz M, Martins S, Tramontina S. Exploring ADHD age-of-onset criterion in Brazilian adolescents. Eur Child Adolesc Psychiatry. 2000;9:212-218.
34. Gjone H, Novik TS. Parental ratings of behavior problems—a twin and general-population comparison. J Child Psychol Psychiatry. 1995;36:1213-1224.
35. Levy F, Hay D, McLaughlin M, Wood C, Waldman I. Twin-sibling differences in parental reports of ADHD, speech, reading, and behavioural problems. J Child Psychol Psychiatry. 1996;37:569.
36. van den Oord EJ, Koot HM, Boomsma DI, Verhulst FC, Orlebeke JF. A twin-singleton comparison of problem behavior in 2 to 3 year-olds. J Child Psychol Psychiatry. 1995;36:449-458.
37. Kendler KS, Martin NG, Heath AC, Eaves LJ. Self-report psychiatric symptoms in twins and their nontwin relatives: are twins different? Am J Med Genet B Neuropsychiatr Genet. 1995;60:588-591.
38. Johnson W, Krueger RF, Bouchard TJ, Jr., McGue M. The personalities of twins: just ordinary folks. Twin Res. 2002;5:125-131.
39. Moilanen I, Linna SL, Ebeling H, *et al.* Are twins' behavioural/emotional problems different from singletons'? Eur Child Adolesc Psychiatry. 1999;8:62-67.