Original Research

Neuropsychological Performance in DSM-IV ADHD Subtypes: An Exploratory Study With Untreated Adolescents

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Objective: To explore neuropsychological performance in untreated Brazilian adolescents suffering from attention-deficit hyperactivity disorder (ADHD).

Method: We assessed 30 untreated adolescents with ADHD and 60 healthy control subjects, aged 12 to 16 years, using a neuropsychological battery including the Wisconsin Card-Sorting Test (WCST), the Stroop Test (ST), the Digit Span, and the Word Span.

Results: We found neuropsychological differences among the DSM-IV ADHD subtypes. Adolescents with the predominantly inattentive subtype (ADHD-I) performed more poorly than did control subjects on both the Digit Span and the ST. On both the Digit Span and the WCST, adolescents with the combined subtype (ADHD-C) presented significantly more impairments than did control subjects. Adolescents with the predominantly hyperactive-impulsive type (ADHD-HI) did not differ significantly from the control subjects in any measure assessed, but had a better performance than did those with ADHD-C on both the Digit Span and the WCST. In addition, adolescents with ADHD-HI performed better on the ST than did adolescents with ADHD-I.

Conclusions: These findings suggest cognitive differences among ADHD subtypes, supporting the diagnostic distinction among them. Adolescents with ADHD-HI do not seem to have significant cognitive deficits.

(Can J Psychiatry 2002; 47: 863–869)

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Clinical Implications

- These neuropsychological findings support the diagnostic distinction among attention-deficit hyperactivity disorder (ADHD) subtypes proposed in the DSM-IV.
- Cross-cultural support for the distinction among subtypes is also provided, because the sample comprised adolescents from a diverse culture.
- The ADHD predominantly hyperactive-impulsive type does not seem to have significant cognitive deficits.

Limitations

- The sample size was small, especially in the 3 groups with ADHD.
- We used several neuropsychological measures.
- We did not assess comorbid conditions.

Key Words: *attention-deficit hyperactivity disorder, neuropsychology, adolescents, ADHD subtypes*

Attention-deficit hyperactivity disorder (ADHD) is one of the most common psychiatric disorders of childhood, affecting 3% to 6 % of school-age children. In addition, it is associated with a higher risk of academic problems; with significant impairment in family and peer relationships; and with high rates of comorbidity with anxiety, depression, conduct problems, and delinquency (1). Moreover, impairments seem to continue through adolescence and adulthood (2,3).

ADHD is associated with neuropsychological difficulties that interfere with the adequate functioning of affected subjects and with their adaptation to the demands of the social milieu (2). There are controversies about the ability of neuropsychological measures to provide a better understanding of brain

mechanisms involved in the disorder (4). Nonetheless, these measures can document clinical differences found among ADHD subjects at a neuropsychological level.

Several investigations have demonstrated more cognitive impairments on neuropsychological tests in subjects with ADHD than in either control subjects or patients without ADHD (5–8). Seidman and others found that subjects with ADHD demonstrated significantly more impairment on both the Wisconsin Card-Sorting Test (WCST) and the Stroop Test (ST) than did control subjects, regardless of various psychiatric comorbidities (9). However, previous neuropsychological studies have important shortcomings. First, several investigations have shown modifications of the cognitive performance in patients with ADHD following pharmacologic treatment (10–14). As a result, the cognitive assessment in medicated subjects with ADHD has been a significant limitation in the previous literature (9,12,15,16). Second, because most studies were conducted with referred samples (5,17,18), referral bias limits the degree to which findings can be generalized (nonreferred samples represent more fully the distribution of symptom severity). Third, previous studies included mixed samples of children and adolescents (7,18). Because differences in cognitive functioning may occur according to the developmental stage, studies with homogeneous age samples are needed. Finally, investigations of neuropsychological performance in children and adolescents with ADHD from cultures outside the US or other developed countries are scarce. Considering that cultural factors may modulate the clinical manifestation of disruptive behaviour disorders (19,20), differences in neuropsychological performance among subjects from different cultures should also be evaluated.

Successive revisions of the DSM have taken several approaches to the clinical heterogeneity of ADHD. The latest edition (DSM-IV) (21) describes 3 subtypes of ADHD: inattentive (ADHD-I), hyperactive-impulsive (ADHD-HI), and combined (ADHD-C). Although these subtypes were developed empirically from the DSM-IV field trials (22), little is known about their diagnostic validity for use in either clinical or research settings. The primary motivation for identifying the DSM-IV subtypes was factor-analysis literature consistently showing that only 2 dimensions were needed to explain the covariation of ADHD symptoms (that is, inattention and hyperactivity-impulsivity) (22–24).

Several studies have demonstrated that the subtypes ADHD-C and ADHD-I, which display inattention symptoms as a significant part of the clinical presentation, seem to be associated with more academic problems than are found in either the ADHD-HI subtype or in control subjects without ADHD (18,25,26). For example, Baumgaertel and others surveyed 1077 elementary school students, using behaviour ratings from teachers (27). Among the children with ADHD, those with the inattentive subtype were more likely to be rated as below average or failing in school (63%) than were children with the combined (50%) or hyperactive-impulsive (12%) subtypes. This clinical evidence suggesting differences among ADHD subtypes indicates the relevance of exploring possible differences in their cognitive profiles.

In this regard, Barkley suggests that even inattention is qualitatively different among ADHD subtypes (28). He proposes that the poor sustained attention which apparently characterizes those with ADHD-C probably represents impaired goal- or task-directed persistence arising from poor inhibition, which takes a toll on self-regulation and disrupts broad executive functions. Conversely, ADHD-I (typically characterized as daydreaming, spacey, easily confused, in a fog, or staring) is most likely to reflect deficits in speed of information processing and in selective attention. Thus, according to Barkley's model, 2 qualitatively different disorders are currently classified under the general construct of ADHD.

Despite the clinical evidence documenting differences among ADHD subtypes and the existence of a theoretical model proposing that the neuropsychological mechanisms associated with inattention might be different for ADHD-C and ADHD-I, few studies have examined differences in the neuropsychological profiles of the ADHD subtypes. Before DSM-IV (21), only 3 controlled studies evaluated differences among ADHD subtypes according to specific neuropsychological tests. One of these investigations found no evidence to support different cognitive profiles among the subtypes (29). The other 2 showed significant differences in a few variables only—too few to indicate that ADHD subtype strongly influenced neuropsychological performance (30,31). After publication of the DSM-IV, Faraone and others assessed neuropsychological performance to verify differences among DSM-IV subtypes in children and adolescents (18). On psychometric measures of intellectual functioning and academic achievement, subjects with each subtype showed more impairment than did subjects without ADHD. These differences were significant for ADHD-C and ADHD-I. In measures of neuropsychological functioning among the 3 ADHD subtypes, however, they found no differences. Recently, Klorman and others compared patients with ADHD-I and ADHD-C for performance in executive functions (7). They found that the performance of patients with ADHD-C was significantly worse. However, Gadow and others did not find significant differences when they used a battery of 6 measures to test neuropsychological performance among DSM-IV subtypes in a sample of young adolescents with ADHD (32). Therefore, possible differences in neuropsychological performance among ADHD subtypes are still unclear.

In this exploratory study, we assess neuropsychological performance in a sample of untreated Brazilian adolescents with ADHD. Based on the literature, we hypothesized that 1) the group with ADHD-HI would not present significantly more impairments on neuropsychological measures of executive function and selective attention, compared with control subjects (following the clinical literature); 2) the ADHD groups with clinically significant inattention (ADHD-I and ADHD-C) would present significantly more deficits on those neuropsychological measures, compared with control subjects; 3) the group with ADHD-I would show the worst performance on neuropsychological measures evaluating selective attention, compared with the other groups (following Barkley's model).

Method

Subjects

The sample was drawn from state schools in Porto Alegre, Brazil. Our study is part of a larger project to evaluate the prevalence of ADHD, its comorbidities, and impairments in youths (3,33,34). Detailed study methodology has been reported elsewhere (3,33). Briefly, we applied a screening instrument for ADHD to a sample of 1013 students obtained through a proportional cluster random sampling based on school size. The screen identified 99 students whom we assessed for ADHD according to DSM-IV criteria. We diagnosed 30 adolescents with ADHD and included 26 in our study. To complete the ADHD groups, we also included 4 adolescents from our ADHD outpatient clinic (2 with ADHD-C, 1 with ADHD-I, and 1 with ADHD-HI). From the same state schools, we randomly selected 60 adolescents without ADHD. Thus, the sample comprised 90 adolescents (30 subjects with ADHD and 60 control subjects) of both sexes. Their ages varied from 12 to 16 years. We excluded subjects if they had an estimated IQ lower than 70, major sensorimotor handicaps, or psychosis. We also excluded any who had been treated for ADHD.

Psychiatric Assessment

The first author and one of the senior authors carried out all diagnostic assessments. These authors are experienced child and adolescent psychiatrists and were blind to the results of the neuropsychological evaluation. Their agreement on DSM-IV ADHD diagnoses had been evaluated previously with 6 subjects (3 with ADHD and 3 healthy subjects) in separate clinical interviews with the adolescents and their families; they achieved 100% agreement for ADHD ($k = 1$, $P < 0.001$). In the study itself, adolescents and their parents were interviewed separately at the university hospital or in the subjects' homes. We obtained written consent from all parents and adolescents. To satisfy diagnostic criteria for ADHD, adolescents had to fully meet all DSM-IV criteria according to adolescent or parent report. This approach has been widely used in other studies (3,33,35). Subjects were assigned to an ADHD subtype by symptom count, taking into consideration information from both parents and adolescents. When adolescent and parent reports disagreed, parent information had priority (36,37). Although we did not assess psychiatric comorbidities in this sample, ADHD was the primary diagnosis for each patient.

Neuropsychological Evaluation

Based on both the literature and our previous experience with neuropsychological assessment, we chose the following neuropsychological battery: 1) to assess broad executive function, the computerized WCST (38); 2) to assess selective attention, the abbreviated version of the ST (39); c) to assess attention, 2 additional specific measures (Digit Span [40] and Word Span [41]).

The WCST is a neuropsychological test that assesses the ability to form abstract concepts, to sustain attention, and to shift cognitive set flexibly in response to changing conceptual rules while inhibiting inappropriate responses. It assesses organizational capacity, attention shifting, and sustained attention. The WCST is generally considered to be sensitive to frontal lobe dysfunction and is one of the most commonly used tests for executive function in the school-aged population (42).

The ST measures the subject's ability to shift perceptual set in response to changing demands and to concentrate selectively or attend in situations requiring inhibition of responses. The precise nature of the information-processing mechanisms revealed by the ST remains controversial, but the potential usefulness of this procedure for evaluating the efficiency of selective attention in ADHD is compelling (5).

The Digit Span provides a simple measure of attention (40). The score reflects the amount of material on which the subject can maintain focus during a given time period. The Word Span requires subjects to repeat immediately a list of words (nouns) just heard (41). This test assesses attention and immediate memory of verbal content. Both tests have been used previously in ADHD studies (8,17,43,44).

All tests were administered and scored by trained examiners who were unaware of subjects' ADHD status. The tests were always given in a fixed order, and the battery required about 30 minutes to administer. Complete data were obtained for all subjects. To estimate the adolescents' overall IQ (3,33), trained psychologists administered the vocabulary and block design subtests of the Weschler Intelligence Scale-Third Edition (40).

We defined socioeconomic status (SES) according to a standard socioeconomic measure frequently used in Brazil, the Socioeconomic Scale of the Brazilian Association of Market Research Institutes (45). The ethical committee of our university hospital approved the project.

Data Analysis

The comparisons among ADHD subtypes and control subjects on both demographic and neuropsychological variables were performed using analysis of variance (ANOVA) for those variables that showed a normal distribution. Differences were located by least-squares means (LSMEANS). To check possible covariates, we performed a partial correlation (residual analysis) among outcome (neuropsychological) variables and both IQ and demographic variables (46). If correlations

were detected, we used Analysis of Covariance (ANCOVA). For variables that did not show a normal distribution, we used the Kruskal-Wallis (KW) 1-way Anova, and differences were located by the Dunn Test (47). We accepted a significance level of 5% in all comparisons in this exploratory study. All statistical tests were carried out using SPSS, version 8.0 for Windows (48) and SAS, version 6.12 for Windows (49).

Results

The demographic data for the overall (n = 30) and specific ADHD groups and the control group (n = 60) can be seen in Table 1. We found no significant differences on demographic variables and IQ among groups, except for education (KW = 9.4, df 3, $P < 0.05$). In post hoc analysis, the difference was located only between adolescents with ADHD-C and control subjects ($Q = 2.64$, $P < 0.05$) (Table 1).

Partial correlation analysis demonstrated the following significant correlations: 1) total of errors score on the WCST and education ($r = –0.26$, $P < 0.05$); 2) Stroop Color-Word (time to complete the test) score and education ($r = –0.43$, $P < 0.001$), age ($r = –0.26$, $P < 0.05$), and SES ($r = 0.33$, $P < 0.01$). We therefore considered these demographic variables covariates in statistical analysis (ANCOVA) that included these neuropsychological tests. No effect of sex and IQ were detected in any measure.

Subjects with ADHD-I or ADHD-C had a worse neuropsychological performance than did control subjects. Subjects with ADHD-HI did not show significant differences on any test of the neuropsychological battery, compared with control subjects.

Regarding the WCST, we detected a significant difference among groups in the total errors score (ANCOVA, $F = 3.02$; df 3; $P < 0.05$). The difference was localized between ADHD-C and the control group (LSMEANS, $P < 0.05$), the ADHD-I group (LSMEANS, $P < 0.05$), and the ADHD-HI group (LSMEANS, $P < 0.01$). We also detected a significant difference among groups in the conceptual responses score (KW = 8.5, df 3, $P < 0.05$). The ADHD-C group showed a lower score than did the control group ($Q = 2.64$, $P < 0.05$) (Table 2).

Regarding the ST, we detected a significant difference among groups in the Color-Word score (KW = 13.8, df 3, $P < 0.01$). The difference was localized between the group with ADHD-I and the control group ($Q = 2.64$, $P < 0.01$). We also detected a significant difference among groups in the amount of time needed to complete the test (ANCOVA, $F = 3.8$; df 3; $P < 0.05$). The group with ADHD-I took more time to complete the test (ANCOVA, $F = 3.8$; df 3; $P < 0.05$) than did the control group (LSMEANS, $P < 0.01$), the ADHD-C group (LSMEANS, $P < 0.01$), and the ADHD-HI group (LSMEANS, $P < 0.05$) (Table 2).

We found a significant difference among groups in the Digit Span (ANOVA, $F = 6.9$; df 3; $P < 0.001$). After post hoc analysis, the differences were located between the control group and both the ADHD-C group (LSMEANS, $P < 0.001$) and the ADHD-I group (LSMEANS, $P < 0.05$). In addition, the group with ADHD-C showed a score that differed significantly from the ADHD-HI group (LSMEANS, $P < 0.01$) (Table 2).

Table 1 Demographic characteristics and IQ of adolescents with ADHD and control subjects

Demographics and IQ	All ADHD (n = 30)	ADHD-HI (n = 10)	ADHD-I (n = 10)	ADHD-C (n = 10)	Controls (n = 60)
Age					
Mean (SD)	14.2 (1.2)	14.4 (1)	14.1 (1.3)	14.1 (1.4)	13.8 (1)
Grade level					
Median	5.0	5.0	4.5	4.0[a]	5.0
Estimated IQ					
Mean (SD)	88.3 (11.1)	91.3 (7.2)	87.8 (15.3)	85.8 (9.8)	92.9 (10.6)
Sex					
Male, female	16, 14	3, 7	6, 4	7, 3	21, 39
Socioeconomic status (%)					
A	6.6	0.0	10.0	10.0	5.0
B	20.0	20.0	10.0	30.0	21.7
C	60.0	60.0	70.0	50.0	60.0
D	13.4	20.0	10.0	10.0	13.3
E	0.0	0.0	0.0	0.0	0.0
Ethnicity (%)					
European descent	73.3	70.0	80.0	70.0	75.0
Non-European descent	26.7	30.0	20.0	30.0	25.0

ADHD = Attention-deficit hyperactivity disorder; ADHD-HI = Predominantly hyperactive-impulsive; ADHD-I = Predominantly inattentive; ADHD-C = Combined.

[a] $P < 0.05$ – versus control subjects

Table 2 Neuropsychological performance in adolescents with ADHD and control subjects: means (SD) and comparison statistics

Tests	ADHD-HI (*n* = 10)	ADHD-I (*n* = 10)	ADHD-C (*n* = 10)	Control subjects (*n* = 60)	Post hoc analyses
Wisconsin Card-Sorting Test					
Total of errors	47.5 (18)	43.4 (14.6)	69.1 (19.7)	50.7 (20)	C > Control subjects[a],HI[a],I[b]
Conceptual responses	51.2 (19.9)	54.9 (17.1)	29.8 (19.7)	49 (20.8)	Control subjects > C[a]
Perseverative responses	23.5 (7.5)	21.5 (6.7)	25.8 (9)	25 (11.1)	
Categories	4.5 (2.3)	3.9 (2.7)	2.2 (1.9)	4 (2.2)	
Stroop					
Word (error score)	0.2 (0.6)	0.8 (1.2)	0.0 (0)	0.4 (1.3)	
Word (time taken to complete the test in seconds)	27.3 (5)	37.9 (32)	30.2 (10.7)	29.3 (8.3)	
Color-Word (error score)	3.4 (4.1)	4.3 (2.9)	2 (2.5)	1.6 (2.3)	I > Control subjects[b]
Color-Word (time taken to complete the test in seconds)	70.5 (14.7)	91.9 (36)	69.6 (14.2)	68.6 (13.3)	I > HI[a],C[b], and Control subjects[b]
Digit Span	5.9 (2.5)	4.7 (1.9)	3.3 (0.7)	6.3 (2.2)	Control subjects > I[a],C[c]; HI > C[b]
Word Span	5.8 (1.3)	5.6 (1.3)	5.1 (1.1)	5.6 (1.1)	

ADHD = Attention-deficit hyperactivity disorder; ADHD-HI = Predominantly hyperactive-impulsive; ADHD-I = Predominantly inattentive; ADHD-C = Combined.

[a]$P < 0.05$; [b]$P < 0.01$; [c]$P < 0.001$

Discussion

In our sample, adolescents with ADHD-HI did not show significant differences in any neuropsychological measure, compared with the control subjects. Because significant differences were found when the 2 other groups (ADHD-I and ADHD-C) and the control subjects were compared, neuropsychological impairment seems to occur only in those ADHD subtypes wherein inattention is clinically significant. Moreover, adolescents with ADHD-I presented significant impairments on a neuropsicological test that assesses selective attention, and adolescents with ADHD-C performed worst on a more broad measure of executive function.

Our findings on neuropsychological impairment according to ADHD subtype agree with other recent reports (7,18). Assessing cognitive performance in children and adolescents with ADHD, Faraone and others found significant differences for the combined and inattentive subtypes, compared with control subjects (18). However, they were not able to find significant differences among the 3 subtypes. In contrast, when Gadow and others compared a sample of nonreferred adolescents, they were not able to find significant differences among the neuropsychological performance of DSM-IV ADHD subtypes and control subjects (32). In this study, however, subjects were allocated to ADHD subtype groups according to DSM-IV ADHD criterion A only; that is, the list of symptoms. Impairment and pervasiveness of symptoms criteria were not assessed. As a result, significant differences in neuropsychological measures might not have been detected among the groups because mild cases might have been overrepresented in the ADHD groups.

The group with ADHD-HI did not show significant impairment in any neuropsychological measure, compared with the 2 other subtype groups and the control subjects. Thus, the findings from this exploratory study suggesting neuropsychological deficits only in ADHD subtypes where inattention is significantly present concur with studies that have demonstrated more academic impairments in subjects with ADHD-I and ADHD-C, but not in subjects with ADHD-HI (18,25,26,50). It therefore seems that the hyperactive dimension of symptoms is not linked to significant cognitive problems.

In our study, adolescents with ADHD-C showed the worst performance on the WCST, and those with ADHD-I presented the worst performance on the ST. Thus, it is possible to speculate that these findings support the idea that ADHD-C is associated with a more diffuse cognitive impairment, because the WCST is a more comprehensive test of cognitive function (38). The performance of the ADHD-I group on the ST supports Barkley's model for ADHD, suggesting that inattention in this ADHD type may be associated with more specific deficits of selective attention and that inattention may be qualitatively different in ADHD-C, involving more broad deficits of executive functions.

Limitations

Our findings should be understood in the context of some limitations. First, we applied several neuropsychological tests, and this could have increased the possibility of a type I error. However, the significant differences in neuropsychological performance on several tests among ADHD subtypes and control subjects were consistently in the same direction.

Moreover, even when we adjusted for multiple comparisons (Bonferroni's correction), significant differences among groups remained on both the ST Color-Word score and the Digit Span (data not shown). Second, the sample size of the ADHD subtype groups was small, limiting our statistical power. Even so, we detected significant differences among the groups. This is an exploratory study, however, and findings need to be replicated in other samples. Third, the group with ADHD-HI presented a higher rate of adolescent girls than all other groups (although the difference did not reach statistical significance, probably owing to sample sizes). The lack of significant differences in the neuropsychological profile between that group and the control subjects could be attributed to a confounding effect of sex (for example, adolescent girls might present lower impairment than adolescent boys on neuropsychological tests). However, a previous investigation did not find significant differences in neuropsychological functioning between boys and girls with ADHD (51). As well, we detected no effect of sex in neuropsychological tests in our study. Finally, we did not assess comorbidities in our sample, but several previous studies have documented that other psychiatric disorders do not significantly interfere with neuropsychological performance in subjects with ADHD (7,15–17,52–54).

The unmedicated subjects with ADHD-I and ADHD-C presented higher impairments than the control subjects in a sample of adolescents aged 12 to 16 years, drawn from a diverse culture. In addition, ADHD-HI seems not to have significant cognitive deficits. Thus, our findings support the validity of the nosological distinction among ADHD subtypes proposed by DSM-IV and also provide cross-cultural support for this distinction. More studies evaluating the neuropsychological performance in different ADHD subtypes from different age ranges and cultures are needed, as are investigations to evaluate neuroimaging, genetics, and treatment findings according to ADHD neuropsychological subtypes.

Funding Support

This work was partially supported by a research grant from CNPq.

References

1. Barkley RA, Fischer M, Edelbrock CS, Smallish L. The adolescent outcome of hyperactive children diagnosed by research criteria: I. An 8-year prospective follow-up study. J Am Acad Child Adolesc Psychiatry 1990;29:546–57.
2. Mannuzza S, Gittelman-Klein R, Horowitz-Konig P, Giampino TL. Hyperactive boys almost grown up: IV. Criminality and its relationship to psychiatric status. Arch Gen Psychiatry 1989;46:1073–9.
3. Rohde LA, Biederman J, Busnello EA, Zimmermann H, Schmitz M, Martins S, and others. ADHD in a school sample of Brazilian adolescents: a study of prevalence, comorbid conditions, and impairments. J Am Acad Child Adolesc Psychiatry 1999;38:716–22.
4. Oosterlaan J, Logan GD, Sergeant J. Response inhibition in AD/HD, CD, Comorbid AD/HD+CD, anxious, and control children: a meta-analysis of studies with the Stop Task. J Child Psychol Psychiatry 1998;39:411–25.
5. Carter CS, Krener P, Chaderjian M, Northcutt C, Wolfe V. Abnormal processing of irrelevant information in attention deficit hyperactivity disorder. Psychiatry Res 1995;56:59–70.
6. Grodzinsky G, Diamond R. Frontal lobe functioning in boys with attention deficit hyperactivity disorder. Dev Neuropsychol 1992;8:427–45.
7. Klorman R, Hazel-Fernandez LA, Shaywitz SE, Fletcher JM, Marchione KE, Holahan JM, and others. Executive functioning deficits in attention deficit hyperactivity disorder are independent of oppositional defiant or reading disorder. J Am Acad Child Adolesc Psychiatry 1999;38:1148–55.
8. Pine DS, Wasserman GA, Workman SB. Memory and anxiety in prepubertal boys at risk for delinquency. J Am Acad Child Adolesc Psychiatry 1999;38:1024–31.
9. Seidman LJ, Biederman J, Faraone SV, Weber W, Ouellette C. Toward defining a neuropsychology of attention deficit hyperactivity disorder: performance of children and adolescents from a large clinically referred sample. J Consult Clin Psychol 1997;65:150–60.
10. Musten LM, Firestone P, Pisterman S, Bennett S, Mercer J. Effects of methylphenidate on preschool children with ADHD: cognitive and behavioral functions. J Am Acad Child Adolesc Psychiatry 1997;36:1407–15.
11. Tannock R, Ickowicz A, Schachar R. Differential effects of methylphenidate on working memory in ADHD children with and without comorbid anxiety. J Am Acad Child Adolesc Psychiatry 1995;34:886–96.
12. Berman T, Douglas VI, Barr RG. Effects of methylphenidate on complex cognitive processing in attention deficit hyperactivity disorder. J Abnorm Psychol 1999;108:90–105.
13. Douglas VI, Barr RG, Amin K, O'Neill ME, Britton BG. Dosage effects and individual responsivity to methylphenidate in attention deficit disorder. J Child Psychol Psychiatry 1998;29:453–75.
14. Gualtieri CT, Keenan PA, Chandler M. Clinical and neuropsychological effects of desipramine in children with attention deficit hyperactivity disorder. J Clin Psychopharmacol 1991;11:155–9.
15. Seidman LJ, Biederman J, Faraone SV, Milberger S, Norman D, Seiverd K, and others. Effects of family history and comorbidity on the neuropsychological performance of children with ADHD: preliminary findings. J Am Acad Child Adolesc Psychiatry 1995;34:1015–24.
16. Seidman LJ, Benedict KB, Biederman J, Bernstein JH, Seiverd K, Milberger S, and others. Performance of children with ADHD on the Rey-Osterrieth complex figure: a pilot neuropsychological study. J Child Psychol Psychiatry 1995;36:1459–73.
17. Seidman LJ, Biederman J, Faraone SV, Weber W, Mennin D, Jones J. A pilot study of neuropsychological function in girls with ADHD. J Am Acad Child Adolesc Psychiatry 1997;36:366–73.
18. Faraone SV, Biederman J, Weber W, Russel R. Psychiatric, neuropsychological, and psychosocial features of DSM-IV subtypes of attention deficit hyperactivity disorder: results from a clinically referred sample. J Am Acad Child Adolesc Psychiatry 1998;37:185–93.
19. Livingston R. Cultural issues in diagnosis and treatment of ADHD. J Am Acad Child Adolesc Psychiatry 1999;38:1591–4.
20. Reid R. Assessment of ADHD with culturally different groups: the use of behavioral rating scales. School Psychology Review 1995;24:537–60.
21. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 4th ed. Washington (DC): American Psychiatric Press; 1994.
22. Lahey B, Applegate B, McBurnett K, Biederman J, Greenhill L, Hynd GW, and others. DSM-IV field trials for attention deficit/hyperactivity disorder in children and adolescents. Am J Psychiatry 1994;151:1673–85.
23. Lahey B, Pelham WE, Schaughency EA, Atkins MS, Murphy HA, Hynd G, and others. Dimensions and types attention deficit disorder with hyperactivity in children: a factor and cluster-analytic approach. J Am Acad Child Adolesc Psychiatry 1988;27:330–5.
24. Bauermeister J, Alegria M, Bird H, Rubio-Stipec M, Canino G. Are attention-hyperactivity deficits unidimensional or multidimensional syndromes? Empirical findings from a community survey. J Am Acad Child Adolesc Psychiatry 1992;31:423–31.
25. Gaub M, Carlson CL. Behavioral characteristics of DSM-IV ADHD subtypes in a school-based population. J Abnorm Child Psychol 1997;25:103–11.
26. Marshall RM, Hynd GW, Handwerk MJ, Hall J. Academic underachievement in ADHD subtypes. J Learn Disabil 1997;30:635–42.
27. Baumgaertel A, Wolraich M, Dietrich M. Comparison of diagnostic criteria for ADHD in a German elementary school sample. J Am Acad Child Adolesc Psychiatry 1995;34:629–38.
28. Barkley R. Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. Psychol Bull 1997;121(1):65–94.
29. Carlson CL, Lahey BB, Neeper R. Direct assessment of the cognitive correlates of attention deficit disorders with and without hyperactivity. Journal of Psychopathology and Behavioral Assessment 1986;8:69–86.
30. Barkley RA, Grodzinsky G, DuPaul GJ. Frontal lobe functions in attention deficit disorder with and without hyperactivity: a review and research report. J Abnormal Child Psychol 1992;20:163–88.
31. Trommer BL, Hoeppner JB, Lorber R, Armstrong KJ. The go-no-go paradigm in attention defict disorder. Ann Neurol 1988;24:610–4.
32. Gadow KD, Nolan EE, Litcher L, Carlson GA, Panina M, Golovakha L, and others. Comparison of attention-deficit/hyperactivity disorder symptom subtypes in Ukrainian schoolchildren. J Am Acad Child Adolesc Psychiatry 2000;39:1520–7.
33. Rohde LA, Biederman J, Zimmermann H, Schmitz M, Martins S, Tramontina S. Exploring ADHD age-of-onset criterion in Brazilian adolescent. Eur J Child Adolesc Psychiatry 2000;9:212–8.
34. Rohde LA, Barbosa G, Polanczyk G, Eizirik M, Rasmussen ER, Neuman RJ, and others. factor and latent class analysis of dsm-iv adhd symptoms in a School

Sample of Brazilian adolescents. J Am Acad Child Adolesc Psychiatry 2001;40:711–8.
35. Offord DR, Boyle MH, Racine Y, Szatmari P, Fleming JE, Sanford M, and others. Integrating assessment data from multiple informants. J Am Acad Child Adolesc Psychiatry 1996;35:1078–85.
36. Dulcan M. Practice parameters for the assessment and treatment of children, adolescents, and adults with attention-deficit/hyperactivity disorder. J Am Acad Child Adolesc Psychiatry 1997;36 (10 Suppl): 85S–121S.
37. Rohde LA, Biederman J, Knijnik M, Chachamovich E, Pinzon V, Ketzer C, and others. Exploring different information sources for DSM-IV ADHD diagnoses in Brazilian adolescents. Journal of Attention Disorders 1999;3:91–6.
38. Heaton RK, Chelune GJ, Talley JL, Kay GG, Curtis G. Wisconsin Card Sorting Test (WCST) manual revised and expanded. Odessa (FL): Psychological Assessment Resources Inc; 1993.
39. Liddle PF, Morris DL. Schizophrenic syndromes and frontal lobe performance. Br J Psychiatry 1991;158:340–5.
40. Wechsler D. WISC III/manual. New York: The Psychological Corporation; 1991.
41. Ceitlin L, Santos B, Parisotto L, Zanatta R, Chaves MLF. Elaboration of word lists in portuguese with emotional content and their influence of memory function in normal subjects. International Journal of Methods in Psychiatry Research 1995;5:195–203.
42. Ozonoff S, Pennington BF, Rogers SJ. Executive function deficits in high-functioning autistic individuals: relationship to theory of mind. J Child Psychol Psychiatry 1991;32:1081–105.
43. Reinecke MA, Beebe DW, Stein MA. The third factor of the WISC-III: It's (probably) not freedom from distractibility. J Am Acad Child Adolesc Psychiatry 1999;38:322–8.
44. Holdnack JA, Moberg PJ, Arnold SE, Gur RC, Gur RE. Speed of processing and verbal learning deficits in adults diagnosed with attention deficit disorder. Neuropsychiatry Neuropsychol Behav Neurol 1995;8:282–92.
45. Galduróz JCF, Noto AR, Carlini EA. IV Levantamento sobre o uso de drogas entre estudantes de 1o e 2o graus em 10 capitais brasileiras. Sao Paulo (BR): Centro Brasileiro de Informaç es sobre Drogas Psicotrópicas; 1997.
46. Morrison DF. Multivariate statistical method. 3rd ed. New York (NY): McGraw-Hill; 1990.
47. Daniel WW. Applied nonparametric statistics. Boston: PWS/KENT; 1990.
48. SPSS. Statistical package for social sciences for windows. Release 8.0. Chicago: SPSS Inc; 1997.
49. SAS. Version 6.12. Cary (NC): SAS Institute Inc; 1996.
50. Wolraich ML, Hannah JN, Pinnock TY, Baumgaertel A, Brown J. Comparison of diagnostic criteria for attention-deficit hyperactivity disorder in a county-wide sample. J Am Acad Child Adolesc Psychiatry 1996;35:319–24.
51. Sharp WS, Walter JM, Marsh WL, Ritchie GF, Hamburger SD, Castellanos FX. ADHD in girls: clinical comparability of a research sample. J Am Acad Child Adolesc Psychiatry 1999;38:40–7.
52. Newcorn JH, Halperin JM, Jensen PS, Abikoff HB, Arnold E, Cantwell DP, and others. Symptom profiles in children with ADHD: effects of comorbidity and gender. J Am Acad Child Adolesc Psychiatry 2001;40:137–46.
53. Nigg JT, Hinshaw SP, Carte ET, Treuting J. Neuropsychological correlates of childhood attention deficit hyperactivity disorder: explainable by comorbid disruptive behavior or reading problems? J Abnorm Psychol 1998;107:468–80.
54. Schachar R, Tannock R. Test of four hypotheses for the comorbidity of attention deficit hyperactivity disorder and conduct disorder. J Am Acad Child Adolesc Psychiatry 1995;34:639–48.

Manuscript received February 2002, revised, and accepted August 2002.
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Résumé : Le rendement neuropsychologique dans les sous-types du THADA du *DSM-IV* : une étude exploratoire chez des adolescents non traités

Objectif : Examiner le rendement neuropsychologique d'adolescents brésiliens non traités souffrant du trouble d'hyperactivité avec déficit de l'attention (THADA).

Méthode : Nous avons évalué 30 adolescents non traités souffrant du THADA et 60 sujets témoins en santé, âgés de 12 à 16 ans, à l'aide d'une batterie de tests neuropsychologiques, dont la classification catégorielle de cartes du Wisconsin (WCST), le test de Stroop (ST), la mémoire immédiate des chiffres et celle des mots.

Résultats : Des différences neuropsychologiques ont été constatées parmi les sous-types du THADA du *DSM-IV*. Les adolescents du sous-type inattention prédominante (THADA-I) avaient un rendement inférieur à celui des sujets témoins, tant à la mémoire immédiate des chiffres qu'au ST. Les adolescents du sous-type mixte (THADA-M) présentaient un nombre significativement plus élevé de déficiences que les sujets témoins à la mémoire immédiate des chiffres et à la WCST. Les adolescents du sous-type hyperactivité-impulsivité prédominante (THADA-HI) ne différaient pas significativement des sujets témoins à n'importe laquelle des mesures évaluées, mais ils avaient un meilleur rendement que ceux du sous-type THADA-M tant à la mémoire immédiate des chiffres qu'à la WCST. En outre, les adolescents du sous-type THADA-HI avaient un meilleur rendement au ST que les adolescents de type THADA-I.

Conclusions : Ces résultats indiquent des différences cognitives parmi les sous-types du THADA, ce qui confirme la distinction diagnostique entre eux. Les adolescents du type THADA-HI ne semblent pas avoir de déficiences cognitives significatives.