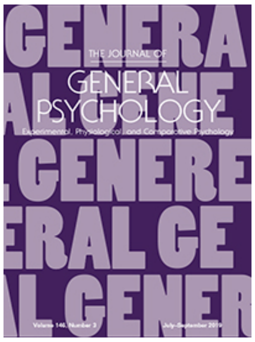

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WISC-III Cognitive Profiles in Children with ADHD: Specific Cognitive Impairments and Diagnostic Utility

Octávio Moura[a], Paulo Costa[b], and Mário R. Simões[a]

[a]University of Coimbra; [b]Leiria Hospital Center

ABSTRACT
This study aimed to investigate the presence of specific cognitive impairments and the diagnostic utility of the WISC-III in children with ADHD. Ninety-eight children with ADHD and 81 children without ADHD matched by age and gender (control group), between the ages of 6 and 12 years, participated in the study. Children with ADHD revealed the most pronounced deficits in the subtests tapping working memory and processing speed. Freedom from Distractibility was the cognitive profile most impaired and that showed the highest diagnostic accuracy to discriminate children with ADHD. The optimal cut-off scores of the most common WISC-III cognitive profiles revealed greater diagnostic accuracy than the traditional approach of full or partial profiles. Taken together, these results suggested that in the context of a comprehensive psychological assessment, the WISC may provide knowledge about the specific cognitive strengths and weaknesses that characterize this disorder and may be useful in the decision-making process relative to ADHD diagnosis.

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Attention-Deficit/Hyperactivity Disorder (ADHD); cognitive profiles; processing speed; WISC; working memory

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders, affecting approximately 5% of children. It is characterized by a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes significantly with the individual's functioning or development. The number and combination of these symptoms can give rise to three types of presentation: predominantly inattentive (ADHD-I), predominantly hyperactive-impulsive (ADHD-HI) and combined (ADHD-C) (American Psychiatric Association, 2013). It has been hypothesized that ADHD results from a dysfunction in the prefrontal-striatal circuitry that underpins deficits in executive functions (Castellanos & Proal, 2012). Numerous studies demonstrate that children with ADHD performed poorly

CONTACT Octávio Moura octaviomoura@gmail.com Psychological Assessment and Psychometrics Laboratory, Faculty of Psychology and Educational Sciences, University of Coimbra, Rua do Colégio Novo, 3000-115, Coimbra, Portugal.
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on measures of working memory (Alloway & Cockcroft, 2014), processing speed (Shanahan et al., 2006; Willcutt, Pennington, Olson, Chhabildas, & Hulslander, 2005), inhibition, and shifting (Moura et al., 2017; Roberts, Martel, & Nigg, 2017), among others.

As a result of the cognitive deficits observed in individuals with ADHD, many studies have tried to identify specific Wechsler Intelligence Scale for Children (WISC) profiles (e.g., Filippatou & Livaniou, 2005; Mayes & Calhoun, 2006; Prifitera & Dersh, 1993). Thus, the present study aimed to analyze the cognitive profiles and the diagnostic utility of WISC-III (Wechsler, 1991, 2003) in children with ADHD using the traditional approach (i.e., group differences, percentages of discrepancies among index scores, and the presence of a pattern of low scores on the subtests included in the most common WISC cognitive profiles) and applying a different approach based on other statistical methods [i.e., receiver operating characteristics (ROC) curve analysis and optimal cutoff scores].

The first attempt to identify specific WISC's cognitive profiles is thought to have been proposed by Bannatyne (1968, 1971). He suggested that WISC subtest scores could be re-categorized into four composite scores (*spatial abilities*: Block Design, Object Assembly and Picture Completion; *conceptual abilities*: Vocabulary, Similarities and Comprehension; *sequential abilities*: Digit Span, Coding and Arithmetic; and *acquired knowledge*: Information, Arithmetic and Vocabulary) and that children with learning disabilities exhibited a specific pattern: spatial abilities > conceptual abilities > sequential abilities. Although the Bannatyne pattern has been investigated mostly in children with reading difficulties yielding mixed results (Moura, Simões, & Pereira, 2014; Smith & Watkins, 2004), some researchers also analyzed its diagnostic utility in children with ADHD. For example, Prifitera and Dersh (1993) found a base rate of 47% in children with ADHD (vs. 13.6% in the WISC-III normative sample) and suggested that the Bannatyne WISC-III pattern is useful for diagnostic purposes. More recently, Hesapçioğlu, Çelik, Özmen, and Yiğit (2016) found significant differences in the spatial abilities and sequential abilities composite scores among children with ADHD and typically developing children, with an odds ratio of 0.761 for the spatial abilities.

Anastopoulos, Spisto, and Maher (1994) were one of the first to analyze the diagnostic utility of the WISC-III Freedom from Distractibility Index[1] (Arithmetic and Digit Span subtests) in identifying children with ADHD. They found that children with ADHD scored significantly lower in the Freedom from Distractibility Index than in either the Verbal Comprehension Index or the Perceptual Organization Index. At an individual level, they observed that 25% of the children with ADHD displayed significant Verbal Comprehension Index–Freedom from Distractibility

Index differences according to the WISC-III manual, and 52% displayed significant Verbal Comprehension Index or Perceptual Organization Index–Freedom from Distractibility Index differences. Mayes and Calhoun (2002, 2004) found that Freedom from Distractibility Index was the lowest index score in 57% of the children with ADHD, the low Freedom from Distractibility Index profile was two times more common in ADHD than in children with any other clinical diagnosis (e.g., autism, learning disabilities, brain injury), and that 78.8% of the children with ADHD exhibited a Freedom from Distractibility Index lower than the WISC-III Full Scale IQ. Hesapçioğlu et al. (2016), using a logistic regression analysis, found an odds ratio of 0.722 suggesting that for a one-unit increase in the score of Freedom from Distractibility the risk of ADHD fell by 27.8%.

Two other WISC cognitive profiles have been extensively investigated in children with ADHD: the ACID (Arithmetic, Coding, Information, and Digit Span subtests) and the SCAD (Symbol Search, Coding, Arithmetic, and Digit Span subtests). Prifitera and Dersh (1993) found that the full ACID pattern (i.e., the four ACID subtests were less than or equal to the scores on the remaining subtests) was more common in the ADHD sample (12.3%) than in the WISC-III standardization sample (1.1%). Filippatou and Livaniou (2005) observed that children with ADHD scored significantly lower on the mean score of ACID than the mean score of the remaining WISC-III subtests, but when a stepwise discriminant function analysis was applied, the ACID profile did not efficiently separate children with ADHD from those without ADHD.

In relation to the SCAD profile, Mayes, Calhoun, and Crowell (1998) identified that for 87.4% (study 1) and 76.9% (study 2) of children with ADHD, the sum of the SCAD subtests was less than the sum of Verbal Comprehension Index and Perceptual Organization Index subtests, with a positive predictive power of 76.5% (study 1) and 81.6% (study 2). In another study, Mayes and Calhoun (2006) also found that children with ADHD performed significantly higher in the Verbal Comprehension Index and Perceptual Organization Index (or Perceptual Reasoning Index in WISC-IV) than Processing Speed Index and Freedom from Distractibility Index (or Working Memory Index in WISC-IV) in WISC-III (medium to large effect sizes; $d = 0.5$ to 1.0) and in WISC-IV (very large effect sizes; $d = 1.6$ to 1.9). In WISC-III, 88% of children with ADHD scored lowest on Freedom from Distractibility Index or Processing Speed Index. Interestingly, Snow and Sapp (2000) observed that a difference of $\geq$ 17 points between Perceptual Organization Index and SCAD was observed in 25.7% of children with ADHD, which contrasts with the low percentage observed in the WISC-III standardization sample (2.6%). Kaufman (1994) recommended the use of the SCAD instead of the ACID because it is less vulnerable to contamination from school learning (i.e., Information subtest) and that the differences between clinical groups (e.g., ADHD and learning disabilities) and typically developing children are largely attributable to the subtests comprising the Freedom from Distractibility Index and Processing Speed Index. We did not find studies that explored optimal cutoff scores for the Freedom from Distractibility, ACID, and SCAD composite scores in children with ADHD.

Surprisingly, although the General Ability Index (a composite score that includes Verbal Comprehension Index and Perceptual Organization Index subtests) was first developed for use with the WISC-III (Prifitera, Weiss, & Saklofske, 1998), only with the publication of the WISC-IV some studies have explored its diagnostic accuracy to correctly identify children with ADHD. The General Ability Index is a useful composite score to estimate overall intellectual ability because it is sensitive to cases in which working memory performance is significantly discrepant from verbal comprehension performance and/or processing speed performance is significantly discrepant from perceptual reasoning performance (Prifitera et al., 1998; Raiford, Weiss, Rolfhus, & Coalson, 2008). Indeed, for some children with ADHD, learning disabilities or other neurodevelopmental disorders, concomitant working memory and processing speed deficits lower the Full Scale IQ (Montes, Allen, Puente, & Neblina, 2010; Poletti, 2016). Thus, the Full Scale IQ–General Ability Index discrepancy and the General Ability Index–Cognitive Proficiency Index discrepancy may provide valuable information in a number of neuropsychological and psychoeducational evaluations. In a technical report on the clinical utility of WISC-IV General Ability Index, it was reported that 65.9% of the children with ADHD displayed a Full Scale IQ < General Ability Index, for 35.4% the discrepancy was 5 points or greater, and for 6.1% the discrepancy was 10 points or greater. Percentages were higher in children with a comorbid diagnosis of ADHD and learning disorder: 73.2%, 43.9%, and 24.4%, respectively (Raiford et al., 2008). Similar findings were also reported for adults with ADHD, with 57.8% showing a WAIS-IV Full Scale IQ < General Ability Index, and for 43.1% a significant discrepancy was observed (Theiling & Petermann, 2016). Based on these findings, it is relevant to analyze the diagnostic utility of the General Ability Index, in WISC-III, to verify whether it replicates the results obtained from WISC-IV or shows a different pattern of results. Inversely, Devena and Watkins (2012), through a ROC curve analysis, found area under the curve (AUC) values ranging between .46 and .64, which suggest a low diagnostic accuracy of the WISC-IV General Ability Index–Cognitive Proficiency Index discrepancy in identifying children with ADHD.

In another line of investigation, confirmatory factor analytic studies have found different factor solutions for WISC-IV in samples of children with ADHD. While some studies have reported that the WISC-IV four-factor model fitted well for children with ADHD (Yang et al., 2013), other studies only found evidences for the use of the Full Scale IQ scores (Gomez, Vance, & Watson, 2016; Styck & Watkins, 2017), and others showed that it is highly unlikely that WISC-IV index score profiles can validly contribute to ADHD assessments (Fenollar-Cortés, López-Pinar, & Watkins, 2018).

The present study

Taken together, these findings lend some support for the diagnostic utility of WISC in ADHD. Indeed, investigating performance in WISC subtests and profile analysis are useful because they may provide knowledge about the specific cognitive strengths and weaknesses that characterize certain disorders, and they may alert psychologists to certain diagnostic possibilities, to the eligibility for the special education system and to the intervention planning (Donders, 1996; Mayes & Calhoun, 2004; Prifitera et al., 1998).

Although new editions of the WISC (-IV and -V) have since been published, the WISC-III continues to be the most recent edition available in many countries (e.g., Greece, Netherlands, Portugal). On the other hand, the large body of research about WISC cognitive profiles have been conducted on English-speaking samples, but it is also particularly important to analyze the presence of such profiles in samples of children whose native language is not English in order to understand which ADHD cognitive deficits may be universal and which are culturally specific. Thus, the present study aimed to investigate the presence of specific cognitive impairments and the diagnostic utility of the WISC-III in children with ADHD. This study extended previous research by: (1) examining the diagnostic utility of WISC-III in Portuguese children with ADHD (no similar studies with the Portuguese version of WISC-III were found); (2) performing ROC curve analysis for the index scores discrepancies and the composite scores of the most common WISC-III cognitive profiles (few studies computed this type of statistical analysis); and (3) identifying optimal cutoff scores with the associated sensitivity and specificity values (to the best of our knowledge, the present study is the first to explore optimal cutoff scores of WISC-III in children with ADHD).

Based on the existing literature, we hypothesized that: (1) children with ADHD would reveal more significant weaknesses in subtests tapping working memory and processing speed (Parke, Thaler, Etcoff, & Allen, 2015; Schwean & Saklofske, 2005; Thaler, Bello, & Etcoff, 2013); (2) discrepancies among index scores and the presence of a pattern of low scores on the subtests included in the Bannatyne, Freedom from Distractibility Index, ACID, and SCAD profiles would demonstrate moderate accuracy to discriminate children with ADHD (Hesapçioğlu et al., 2016; Mayes & Calhoun, 2006); and (3) optimal cutoff scores for the index scores discrepancies and for the composite scores of the most common WISC-III cognitive profiles would reveal more adequate sensitivity and specificity values than the traditional approach (Moura et al., 2014).

Method

Participants

Participants included 179 Portuguese children (73.7% male) between the ages of 6 and 12 years ($M = 8.73$ and $SD = 1.86$) who were in first to seventh grade in school.

In the ADHD group ($n = 98$), 76.5% were male, with a mean age of 8.55 ($SD = 1.92$) of which 36 (36.7%) were diagnosed with ADHD-I, 36 (36.7%) with ADHD-HI, and 26 (26.5%) with ADHD-C, according to the diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders – 5th edition (DSM-5; American Psychiatric Association, 2013).

In the control group ($n = 81$), 70.4% were male, with a mean age of 8.94 ($SD = 1.78$). This group was recruited through contact with schools, teachers, parents, and other participants using a snowball sampling strategy. Children with special educational needs were excluded. The groups were matched by gender $\chi^2(1) = 0.869$, $p = .351$ and by age $\chi^2(6) = 9.623$, $p = .141$.

For both groups, only children who met the following criteria were included in the study: (1) WISC-III Full Scale IQ $\geq$ 80; (2) native speakers of European Portuguese; (3) absence of any visual, hearing, or motor handicap; (4) never having been diagnosed with a language impairment, emotional disturbance, specific learning disorder, oppositional defiant disorder, conduct disorder, neurological impairment, or other psychiatric disorder. All participants attended regular classes in public and private schools.

ADHD – Criteria for inclusion

Children with ADHD were recruited from the Department of Pediatrics of the [withheld for blind review] Hospital Center in Portugal. Diagnosis of ADHD was confirmed by a comprehensive clinical diagnostic assessment made by qualified pediatricians and a psychologist. The diagnostic evaluation included: (1) semistructured interview with parents using the DSM-5 criteria (American Psychiatric Association, 2013); (2) both parent and teacher ratings of at least 1.5 *SD* (T-score $\geq$ 65) above the mean on the ADHD Index of the Conners Rating Scale–Revised (Conners, 1997);

(3) neuropsychological tests of attention and executive functions (e.g., Conners' Continuous Performance Test – 2nd edition, Stroop Color and Word Test, and Tower of London); and (4) other complementary assessments (e.g., Child Behavior Checklist and Teacher's Report Form).

To ensure that WISC-III performance was uninfluenced by psychostimulants (Jepsen, Fagerlund, & Mortensen, 2009), children with ADHD who were prescribed psychostimulants (i.e., methylphenidate) did not receive medication during the week in which the evaluation was performed. This longer period is more stringent than the criterion used by other studies, in which medication was ceased only 24 hours prior to evaluation (Alloway & Cockcroft, 2014; Moura et al., 2017).

Measure and procedures

The WISC-III (Wechsler, 1991) is an individually administered intelligence test for children between the ages of 6 to 16 that includes three composite IQ scores (Full Scale IQ, Verbal IQ, and Performance IQ with a $M = 100$ and $SD = 15$), four index scores (Verbal Comprehension Index, Perceptual Organization Index, Processing Speed Index, and Freedom from Distractibility Index with a $M = 100$ and $SD = 15$) and 13 subtests (Information, Similarities, Arithmetic, Vocabulary, Comprehension, Digit Span, Picture Completion, Coding, Picture Arrangement, Block Design, Object Assembly, Symbol Search, and Mazes with a $M = 10$ and $SD = 3$).

The factor structure of the Portuguese version of WISC-III (Wechsler, 2003), analyzed through exploratory and confirmatory factor analyses, suggested a two-factor (Verbal IQ and Performance IQ) and a three-factor model (Verbal Comprehension Index, Perceptual Organization Index, and Processing Speed Index). As in other countries (e.g., Netherlands and Greece), the Portuguese version of WISC-III does not include the Freedom from Distractibility Index; however, it has been shown that this index score can be relevant in a context of a psychological evaluation of some neurodevelopmental disorders (Moura et al., 2017; Thaler et al., 2013). In order to include this index score in the present study, the Freedom from Distractibility Index was estimated by applying a linear equating method proposed by Tellegen and Briggs (1967) based on data provided in the Portuguese version of the WISC-III Manual. This method is based on a linear scaling of composite subtests scaled scores to obtain deviation quotients that maintain the index score distribution ($M = 100$ and $SD = 15$). This method has been commonly used in studies that analyzed WISC index scores and short forms due to their accurate estimation of composite scores (e.g., Girard, Axelrod, Patel, & Crawford, 2015; van Ool et al., 2018). In the present study, the Mazes subtest was not administered to all participants.

As highlighted earlier, in some neurodevelopmental disorders and special education cases, the General Ability Index may be a slightly higher estimate of overall intellectual ability than the Full Scale IQ because it excludes subtests that are related to processing speed and working memory. Due to its relevance in neuropsychological and psychoeducational evaluations, Prifitera et al. (1998) provided a WISC-III norms table for the General Ability Index, which we used in the present study.

The children were tested in three sessions of approximately 45 minutes, held in a clinic setting scheduled on a regular day. All of the measures were individually administered in a fixed order. The study was approved by the Ethics Committee of the [withheld for blind review] Hospital Center and the Scientific Committee of the Faculty of Psychology and Educational Sciences – University of [withheld for blind review]. Voluntary participation was requested of all participants and the objectives of the study were fully explained. Informed parental consent and child assent were obtained for each evaluation.

Statistical analyses

Statistical analyses were performed using IBM SPSS Statistics 23 and MedCalc 12.7. Independent-samples *t*-tests and univariate analysis of variance (ANOVA) were calculated to investigate the significance of differences in WISC-III scores comparing children with and without ADHD. If the initial ANOVA revealed a significant main effect, planned *post hoc* comparisons were conducted among the groups with a Bonferroni adjustment for multiple comparisons. Cohen's *d* or partial eta-squared ($\eta^2{}_p$) were also calculated to determine the effect size of the differences between groups.

Previous to any of these analyses, each dependent variable was assessed for outliers, normal distribution and homogeneity of variances. No outliers were found in the data. All dependent variables revealed skewness and kurtosis values lower than 1, suggesting normal distribution of the data. The Levene's test of homogeneity of variances was not significant ($p > .05$) in all independent-samples *t*-tests and ANOVAs.

A ROC curve analysis was performed to examine the accuracy with which WISC-III index scores discrepancies and cognitive profiles were able to discriminate between the ADHD group and the control group. The ROC curve analysis is produced by showing the false-positive rate (1-specificity) on the *x* axis and the true-positive rate (sensitivity) on the *y* axis for each possible cutoff score and calculates the AUC. That is, sensitivity and specificity are determined for each cutoff point (Fawcett, 2006). The AUC is the average of the true positive rate, taken uniformly over all possible false positive rates, which ranges between .5 and 1.0

(Krzanowski & Hand, 2009). An AUC value of 1.0 is perfectly accurate because the sensitivity is 1.0 when the false positive rate is .0 whereas an AUC value of .5 reflects a completely random classifier. An AUC of .5 to .7 indicates a poor discrimination, .7 to .8 an acceptable discrimination, .8 to .9 an excellent discrimination, and .9 to 1.0 an outstanding discrimination (Hosmer, Lemeshow, & Sturdivant, 2013).

Results

IQs, Index scores and subtests: Group differences

Statistically significant differences were found between control group and children with ADHD for all IQs and index scores, with the control group outperforming children with ADHD (see Table 1). The largest group difference was observed for Freedom from Distractibility Index with a Cohen's d of 1.10 (i.e., the mean score of the control group is $z = 1.10$ above the mean score of the ADHD group), with 83.7% of children with ADHD having a Freedom from Distractibility Index score below the mean of the control group. At the subscale level, children with ADHD scored significantly lower than control group in eight of the 12 WISC-III subtests, with Digit Span ($d = 0.95$) and Arithmetic ($d = 0.75$) showing the largest group differences.

We also performed a series of ANOVAs contrasting control group and ADHD subtypes (control group vs. ADHD-I vs. ADHD-HI vs. ADHD-C). Significant main effects were found for all IQs and index scores as well for six of the 12 WISC-III subtests. Planned *post hoc* tests revealed significant differences between control group and some ADHD subtypes, but non-significant differences were found among children with ADHD, the exception was the Performance IQ (ADHD-HI > ADHD-C) (see Appendix).

Index scores discrepancies and cognitive profiles: Group differences

As shown in Table 1, significant index scores discrepancies between control group and children with ADHD were found for Full Scale IQ–General Ability Index, Verbal Comprehension Index–Freedom from Distractibility Index, Perceptual Organization Index–Freedom from Distractibility Index, and Processing Speed Index–Freedom from Distractibility Index. Interestingly, children with ADHD scored $\asymp$3 points lower in the Full Scale IQ than the General Ability Index; $\asymp$8 points lower in the Freedom from Distractibility Index than the Verbal Comprehension Index, and $\asymp$4 points lower in the Freedom from Distractibility Index than the Perceptual Organization Index and Processing Speed Index.

Significant group differences were also found for all composite scores of cognitive profiles (control group > children with ADHD), with large effect

Table 1. WISC-III mean scores for control group and ADHD group.

	Control group ($n = 81$)	ADHD group ($n = 98$)	$t(177)$	d
IQs				
Full Scale IQ	103.69 ± 10.05	96.04 ± 10.77	4.873***	0.73
Verbal IQ	105.77 ± 10.24	99.90 ± 10.91	3.681***	0.55
Performance IQ	101.52 ± 10.24	94.65 ± 12.15	4.033***	0.61
Index Scores				
General Ability Index	103.89 ± 8.50	98.89 ± 9.19	3.747***	0.56
Verbal Comprehension Index	105.20 ± 10.46	100.67 ± 11.07	2.789**	0.42
Perceptual Organization Index	100.90 ± 10.01	96.64 ± 12.16	2.522*	0.38
Processing Speed Index	104.01 ± 13.76	96.58 ± 13.69	3.605***	0.54
Freedom from Distractibility Index	105.15 ± 9.93	92.99 ± 12.07	7.257***	1.10
Subtests				
Information	10.38 ± 2.07	9.59 ± 2.53	2.253*	0.34
Similarities	11.25 ± 2.44	10.96 ± 2.62	0.753	0.11
Arithmetic	11.01 ± 2.33	9.27 ± 2.28	5.043***	0.75
Vocabulary	10.78 ± 2.72	9.51 ± 2.67	3.133**	0.47
Comprehension	11.05 ± 2.45	10.67 ± 2.76	0.951	0.14
Digit Span	10.70 ± 2.29	8.40 ± 2.53	6.309***	0.95
Picture Completion	10.60 ± 2.34	10.09 ± 2.79	1.314	0.19
Coding	10.37 ± 2.66	8.85 ± 2.95	3.587***	0.54
Picture Arrangement	10.51 ± 2.70	9.61 ± 2.54	2.272*	0.34
Block Design	9.95 ± 2.12	9.51 ± 2.46	1.267	0.19
Object Assembly	10.22 ± 2.42	9.02 ± 2.85	3.000**	0.45
Symbol Search	11.01 ± 2.96	9.92 ± 2.92	2.476*	0.37
Discrepancies				
FSIQ – GAI	−0.20 ± 4.18	−2.85 ± 5.79	3.439**	0.52
VIQ – PIQ	4.25 ± 10.78	5.24 ± 14.22	−0.520	−0.07
VCI – POI	4.30 ± 11.01	4.03 ± 14.30	0.137	0.02
VCI – PSI	1.19 ± 15.60	4.09 ± 15.41	−1.249	−0.18
VCI – FDI	0.05 ± 11.75	7.68 ± 13.69	−3.954***	−0.60
POI – PSI	−3.11 ± 15.47	0.06 ± 15.40	−1.368	−0.20
POI – FDI	−4.25 ± 11.32	3.65 ± 14.97	−3.912***	−0.59
PSI – FDI	−1.14 ± 15.33	3.59 ± 14.90	−2.085*	−0.31
Cognitive Profiles *(composite scores)*				
Freedom from Distractibility	21.72 ± 3.31	17.66 ± 4.02	7.257***	1.10
ACID	42.47 ± 5.48	36.10 ± 6.99	6.670***	1.01
SCAD	43.10 ± 6.35	36.43 ± 7.21	4.492***	0.98
Spatial Abilities	30.78 ± 4.68	28.62 ± 6.26	2.562*	0.39
Conceptual Abilities	33.07 ± 5.51	31.14 ± 5.74	2.280*	0.34
Sequential Abilities	32.09 ± 4.43	26.51 ± 5.52	7.336***	1.11

Note. *$p < .05$; **$p < .01$; ***$p < .001$. IQ and Index Scores are composite IQs scores ($M = 100$ and $SD = 15$) and Subtests scores are age-adjusted-scaled scores ($M = 10$ and $SD = 3$). FSIQ = Full Scale IQ. VIQ = Verbal IQ. PIQ = Performance IQ. GAI = General Ability Index. VCI = Verbal Comprehension Index. POI = Perceptual Organization Index. PSI = Processing Speed Index. FDI = Freedom from Distractibility Index. FD = Freedom from Distractibility (the sum of the age-adjusted-scaled scores of Arithmetic and Digit Span subtests). ADHD = Attention-Deficit/Hyperactivity Disorder.

sizes in the Bannatyne sequential abilities ($d = 1.11$), Freedom from Distractibility ($d = 1.10$), ACID ($d = 1.01$), and SCAD ($d = 0.98$) composite scores.

ANOVAs contrasting control group and ADHD subtypes revealed significant main effects for several index scores discrepancies and composite scores of cognitive profiles (control group > ADHD subtypes). Once again, non-significant differences were found among children with ADHD (ADHD-I = ADHD-HI = ADHD-C) (see Appendix). These findings may suggest that WISC-III did not adequately differentiate the three ADHD subtypes. Thus, in the following analyses, we will only compare children from the control group to children with ADHD (subtypes will no longer be considered).

Index scores discrepancies and cognitive profiles: Diagnostic accuracy

Although the results from the previous inferential analyses indicated significant group differences (control group > ADHD) with moderate to large effect sizes, it does not imply that index scores discrepancies and cognitive profiles can correctly discriminate the children with and without ADHD. Therefore, four levels of analyses were carried out to determine the diagnostic accuracy of these measures: (1) percentages of discrepancies among IQs and index scores in control group and children with ADHD; (2) sensitivity and specificity values for a pattern of low scores on the subtests included in Freedom from Distractibility, ACID, SCAD and Bannatyne profiles (i.e., full or partial profiles); (4) a ROC curve analysis for the index scores discrepancies and the composite scores of cognitive profiles; and (4) optimal cutoff scores with the associated sensitivity and specificity values.

As reported in Table 2, the Full Scale IQ < General Ability Index were obtained by more than 77% of children with ADHD, and for 39.8% of them the discrepancy was equal to or higher than −5 points (vs. 8.6% of control group). The Verbal Comprehension Index > Freedom from Distractibility Index was observed in 73.5% of children with ADHD; 66.3% of them performed 5 or more points in Verbal Comprehension Index than Freedom from Distractibility Index, and for 46.9% this discrepancy was 10 points or greater (vs. 16% for control group). The Perceptual Organization Index > Freedom from Distractibility Index was observed in more than 60% of children with ADHD; 44.9% performed 5 or more points in Perceptual Organization Index than Freedom from Distractibility Index, and for 32.7% the discrepancy was 10 points or greater (vs. 11.1% for control group). The Freedom from Distractibility Index was the lowest index score for 42.9% of children with ADHD (vs. 11.1% for control group), and 64.3% of them scored lowest on Freedom from Distractibility Index or Processing Speed Index.

Following the traditional approach suggested by Prifitera and Dersh (1993), children were considered to be positive for the full profile when their scores on the four ACID (excluding Symbol Search and Mazes) and SCAD subtests or on the two Freedom from Distractibility subtests were less than or equal to the scores on the remaining subtests. Partial profiles were obtained when the scores on any three of the four ACID and SCAD subtests had to be less than or equal to the scores on the remaining subtests. We also investigated other partial profiles, namely the presence of

Table 2. Percentages of the discrepancies among IQs and Index Scores in control group and ADHD group.

	≤ −10	≤ −5	≤ −1	≥ 1	≥ 5	≥ 10
FSIQ – GAI						
Control group	0	8.6	46.9	38.3	9.9	2.5
ADHD	7.1	39.8	77.6	15.3	3.1	1.0
VIQ – PIQ						
Control group	8.6	19.8	35.8	60.5	46.9	30.9
ADHD	18.4	23.5	33.7	64.3	56.1	43.9
VCI – POI						
Control group	11.1	22.2	30.9	64.2	46.9	35.8
ADHD	21.4	27.6	33.7	64.3	53.1	36.7
VCI – PSI						
Control group	24.7	35.8	46.9	51.9	37.0	29.6
ADHD	17.3	26.5	38.8	57.1	45.9	35.7
VCI – FDI						
Control group	16.0	32.1	48.1	50.6	32.1	16.0
ADHD	11.2	16.3	24.5	73.5	66.3	46.9
POI – PSI						
Control group	27.2	45.7	56.8	37.0	33.3	19.8
ADHD	27.6	38.8	49.0	49.0	38.8	27.6
POI – FDI						
Control group	27.2	55.6	64.2	33.3	21.0	11.1
ADHD	17.3	26.5	36.7	60.2	44.9	32.7
PSI – FDI						
Control group	27.2	43.2	49.4	37.0	27.2	23.5
ADHD	16.3	28.2	34.7	60.2	46.9	31.6

Note. FSIQ = Full Scale IQ. VIQ = Verbal IQ. PIQ = Performance IQ. GAI = General Ability Index. VCI = Verbal Comprehension Index. POI = Perceptual Organization Index. PSI = Processing Speed Index. FDI = Freedom from Distractibility Index. ADHD = Attention-Deficit/Hyperactivity Disorder.

Freedom from Distractibility in the three and four lowest-scoring subtests, and the ACID and SCAD in the five and six lowest-scoring subtests. The Bannatyne pattern was established when children exhibit a specific pattern on Bannatyne's composite measures: spatial abilities > conceptual abilities > sequential abilities.

As shown in Table 3, the full Freedom from Distractibility, ACID, and SCAD profiles misclassified the children with ADHD, only 2% to 5.1% of whom were properly diagnosed (true positive). The Freedom from Distractibility in the four lowest-scoring subtests was the cognitive profile that showed the highest diagnostic accuracy, with a sensitivity of 27.6%, a specificity of 95.1%, a positive predictive power of 87.1% (i.e., 87.1% of children classified as positive are children with ADHD), and a negative predictive power of 52% (i.e., 52% of children classified as negative are children from the control group). In general, these results suggested that the presence of the pattern of low scores on the subtests included in Freedom from Distractibility, ACID, SCAD, and Bannatyne profiles did not efficiently distinguish between children with and without ADHD (low sensitivity values).

Additionally, a ROC curve analysis was performed to determine the diagnostic accuracy of the index scores discrepancies and the composite scores

Table 3. Diagnostic accuracy (in percentages) of full and partial cognitive profiles in children with ADHD.

	True-Positive (Sensitivity)	True-Negative (Specificity)	False-Positive	False-Negative	Positive predictive power	Negative predictive power
Freedom from Distractibility						
full profile	5.1	98.8	1.2	94.9	83.3	46.2
in 3 lowest subtests	16.3	95.1	4.9	83.7	80.0	48.4
in 4 lowest subtests	27.6	95.1	4.9	72.4	87.1	52.0
ACID						
full profile	2.0	100	0	98.0	100	45.8
partial profile	16.3	95.1	4.9	83.7	80.0	48.4
in 5 lowest subtests	7.1	98.8	1.2	92.9	87.5	46.8
in 6 lowest subtests	17.3	93.8	6.2	82.7	77.3	48.4
SCAD						
full profile	4.1	100	0	95.9	100	46.3
partial profile	9.2	93.8	6.2	90.8	64.3	46.1
in 5 lowest subtests	10.2	100	0	89.8	100	47.9
in 6 lowest subtests	16.3	97.5	2.5	83.7	88.9	49.1
Bannatyne pattern	22.4	93.8	6.2	77.6	81.5	50.0

of cognitive profiles (the Bannatyne pattern was not included because it is a dichotomous variable: presence vs. absence). The more accurately a test is able to discriminate between groups (higher AUC values), the more its ROC curve will deviate toward the upper left corner of the graph. Table 4 shows the AUC values, and Figure 1 illustrates the ROC curve for the three composite scores that revealed the highest AUC values. The AUC value for Freedom from Distractibility was .781 (i.e., a randomly selected child with ADHD will have a lower Freedom from Distractibility score than a randomly selected child without ADHD approximately 78.1% of the time), for sequential abilities it was .770, and for ACID it was .752. These three composite scores yielded $.70 \leq \text{AUC}$ values $< .80$, which is classified as "acceptable discrimination" (Hosmer et al., 2013, p. 177).

The results of the ROC curve analyses were also used to determine optimal cutoff scores. The optimal cutoff score is where the overall number of errors (i.e., false positives and false negatives) is minimized (Bewick, Cheek, & Ball, 2004). To select optimal cutoff scores, the Youden index (Youden, 1950) was calculated (J = sensitivity + specificity – 1) and the cutoff score associated with the highest J value is considered to indicate the optimal cutoff score. Graphically, J is the maximum vertical distance between the ROC curve and the diagonal line. The optimal cutoff score of the Freedom from Distractibility ($\leq$ 17) revealed the highest Youden index (J = .404), which yielded a sensitivity of 49% and a specificity of 91.4%. Sequential abilities, ACID, SCAD, and the discrepancy Full Scale IQ – General Ability Index also produce optimal cutoff scores with interesting sensitivity ($\geq$ 39.8%) and specificity ($\geq$ 82.7%) values. Table 4 shows the optimal cutoff score for the index scores discrepancies and composite score of cognitive

Table 4. ROC curve analysis and optimal cutoff scores for discrepancies and for the composite scores of cognitive profiles.

	AUC (95% CI)	Optimal Cut-off Score	Youden Index (*J*)	Sensitivity (%)	Specificity (%)
Discrepancies					
FSIQ – GAI	.705 (.632–.770)***	≤ −5	.311	39.8	91.4
VIQ – PIQ	.541 (.465–.616)	≥ 9	.156	49.0	66.7
VCI – POI	.508 (.433–.584)	≥ −11	.115	78.6	9.9
VCI – PSI	.556 (.480–.631)	≥ −3	.107	66.3	44.4
VCI – FDI	.684 (.611–.751)***	≥ 5	.342	66.3	67.9
POI – PSI	.555 (.480–.630)	≥ 2	.131	49.0	64.2
POI – FDI	.671 (.597–.740)***	≥ −5	.291	73.5	55.6
PSI – FDI	.607 (.531–.679)	≥ 1	.231	60.2	63.0
Cognitive Profiles *(composite scores)*					
FD	.781 (.713–.839)***	≤ 17	.404	49.0	91.4
ACID	.752 (.682–.814)***	≤ 36	.387	51.0	87.7
SCAD	.747 (.677–.809)***	≤ 37	.317	49.0	82.7
Spatial Abilities	.613 (.538–.685)**	≤ 26	.204	37.8	82.7
Conceptual Abilities	.593 (.517–.665)*	≤ 29	.173	40.8	76.5
Sequential Abilities	.770 (.701–.829)***	≤ 27	.379	49.0	88.9

Note. *$p < .05$; **$p < .01$; ***$p < .001$. AUC = area under the curve. FSIQ = Full Scale IQ. GAI = General Ability Index. VCI = Verbal Comprehension Index. POI = Perceptual Organization Index. PSI = Processing Speed Index. FDI = Freedom from Distractibility Index. FD = Freedom from Distractibility.

profiles. These results showed greater diagnostic utility of the composite scores than the presence of full or partial profiles.

Discussion

The Wechsler intelligence scales are considered to be the gold standard measures of intellectual functioning. While the Wechsler intelligence scales do not diagnose ADHD (nor were they ever were intended to do so), several studies have analyzed their utility in the psychological assessment of individuals with ADHD. It has been extensively reported in the literature that in addition to inattention and hyperactivity-impulsivity symptoms, children with ADHD revealed specific cognitive impairments (Moura et al., 2017; Roberts et al., 2017; Willcutt et al., 2005). Thus, because the WISC-III may be useful to analyze the cognitive strengths and weaknesses in children with ADHD, the present study investigated their diagnostic accuracy to correctly discriminate children with and without ADHD.

In a meta-analytic study, Frazier, Demaree, and Youngstrom (2004) reported that overall intellectual ability of individuals with ADHD is significantly lower than healthy participants, with a weighted mean effect size of $d = 0.61$ for Full Scale IQ, $d = 0.67$ for Verbal IQ, and $d = 0.58$ for

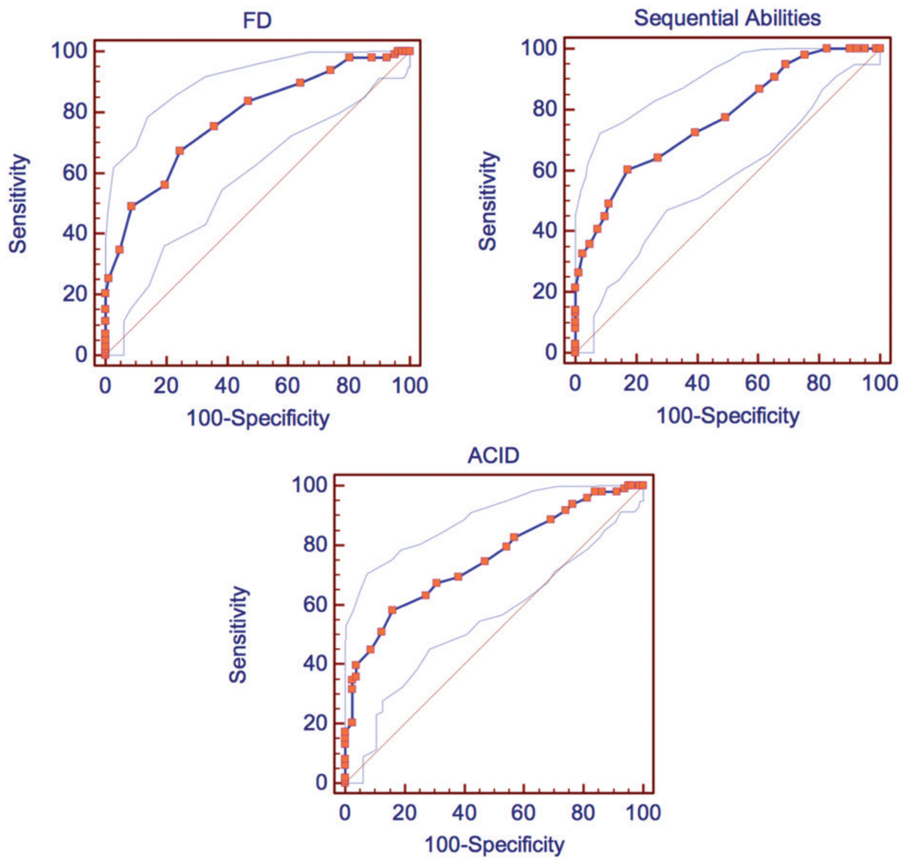

Figure 1. ROC curve analysis comparing true- and false-positive rates between children with and without ADHD in the Freedom from Distractibility (FD), Sequential Abilities and ACID composite scores. Dashed lines represent 95% confidence interval lines.

Performance IQ. It means that the ADHD groups performed at approximately 9 Full Scale IQ points lower than the control groups if a theoretical *SD* of 15 is assumed. Interestingly, they observed that the magnitude of the effect sizes for several neurocognitive measures of attention, working memory, and behavioral inhibition was equivalent or smaller than that obtained for Full Scale IQ. In our study, we also found that WISC-III Full Scale IQ was significantly lower in children with ADHD than in control group (Δ = 7.65 points, $d = 0.73$), as well the Verbal IQ (Δ = 5.87 points, $d = 0.55$) and Performance IQ (Δ = 6.87 points, $d = 0.61$). This finding is relevant given the fact that some confirmatory factor analytic studies with children with ADHD recommended that interpretation of the WISC (particularly for WISC-IV) should remain at the Full-Scale IQ score level (Devena, Gay, & Watkins, 2013; Fenollar-Cortés et al., 2018; Gomez et al., 2016; Styck & Watkins, 2017). It is well-known that performance on the WISC is particularly influenced by executive functions because they include some subtests that assess working memory and processing speed abilities. Executive functions may also influence the performance on the WISC subtests through alterations in response style and problems with the inhibitory control, cognitive flexibility, planning, and self-regulation, among others (Kaufman & Lichtenberger, 2000). In addition, inattention problems may also explain the lower IQ scores observed in children with ADHD. Jepsen et al. (2009) estimated that the inattention-related mean influence on Full Scale IQ may be in the 2- to 5-point range. Deficits on academic achievement, language, verbal and visuospatial memory are commonly encountered in individuals with ADHD (Alloway & Cockcroft, 2014; Kasper, Alderson, & Hudec, 2012; Moura et al., 2017), which may also reduce the IQs and index scores.

Interestingly, the performance on the WISC-III (IQs, index scores, subtests, and cognitive profiles) were not significantly different in the three ADHD subtypes. This finding suggests that in our sample, WISC-III did not find independent subgroups of children with ADHD. In their meta-analytic study, Frazier et al. (2004) also found that ADHD subtypes did not significantly differ on Full Scale IQ. Mayes, Calhoun, Chase, Mink, and Stagg (2009) identified similar performance between children with ADHD-C and ADHD-I in the Freedom from Distractibility Index (95 and 93, respectively), Processing Speed Index (99 and 97, respectively), and in the discrepancy Full Scale IQ – Freedom from Distractibility Index (12 and 14, respectively). Several other studies have investigated the performance on a variety of cognitive measures between ADHD subtypes, and the results have shown that the ADHD-I, ADHD-HI, and ADHD-C exhibit more similarities than differences (Bernfeld, 2012; Fenollar-Cortés, Navarro-Soria, González-Gómez, & García-Sevilla, 2014; Koziol & Budding, 2012; Riccio, Homack, Jarratt, & Wolfe, 2006; Solanto et al., 2007). For example, Chhabildas, Pennington, and Willcutt (2001) observed that children with ADHD-I and ADHD-C had similar deficits in tasks that require assessing inhibition, processing speed, and vigilance, whereas children with ADHD-HI were not significantly impaired from carrying out any of these tasks once subclinical symptoms of inattention were controlled. The ADHD-I did not differ from ADHD-C in the WISC-R Full Scale IQ, Verbal IQ and Performance IQ scores. In a meta-analytic study, Willcutt et al. (2012) did not find evidences for the validity of ADHD-H after first grade and for the presence of distinct academic and cognitive functioning between ADHD-I and ADHD-C. Moreover, they did not identify ADHD subgroups with sufficient long-term stability to justify the classification of distinct forms/subtypes of this neurodevelopmental disorder. Obviously, the diagnosis of ADHD subtypes is particularly influenced by clinicians' decisions regarding informants, instruments, and the method for aggregating information across informants and instruments (Valo & Tannock, 2010), but is also unstable over time (Lahey, Pelham, Loney, Lee, & Willcutt, 2005), which may explain the mixed findings reported in literature with regard to the endophenotype of ADHD subtypes.

Although inferential analysis showed significant group differences for almost all WISC-III scores, children with ADHD revealed most pronounced weaknesses in subtests tapping working memory and processing speed. The Freedom from Distractibility Index was the index score most impaired in children with ADHD ($d = 1.10$); the three subtests with the highest effect sizes were Digit Span, Arithmetic, and Coding; the Freedom from Distractibility, ACID, SCAD and Sequential Abilities cognitive profiles are significantly reduced in children with ADHD; and approximately two-thirds of children with ADHD scored lowest on Freedom from Distractibility Index or Processing Speed Index. These findings are consistent with the first hypothesis and have been extensively reported in literature (Hesapçioğlu et al., 2016; Mayes & Calhoun, 2006; Parke et al., 2015; Schwean & Saklofske, 2005; Snow & Sapp, 2000; Thaler et al., 2013).

Although children with ADHD performed significantly lower than control group for almost all WISC-III scores, the presence of a significant difference alone does not imply that a subtest or an index/composite score can discriminate among subjects with sufficient accuracy. Thus, additional analyses were performed in order to investigate the accuracy of the WISC-III in the diagnosis of children with ADHD. We hypothesized that the discrepancies among index scores would demonstrate moderate accuracy to discriminate children with ADHD, which was partially confirmed. Indeed, for a large number of children with ADHD, concomitant working memory and processing speed deficits lower the Full Scale IQ. More than 77% of children with ADHD showed a Full Scale IQ lower than the General Ability Index. The AUC value of .705 indicates acceptable discrimination accuracy in terms of group classification (Hosmer et al., 2013), and a discrepancy of −5 points or greater was identified as the optimal cutoff score with a sensitivity of 39.8% and a specificity of 91.4%. Similar results were reported by Raiford et al. (2008) based on the WISC-IV Technical and Interpretive Manual: 65.9% of the children with ADHD displayed a Full Scale IQ < General Ability Index, and for 35.4% the discrepancy was −5 points or greater. Following the original proposal of Prifitera et al. (1998), we found that the General Ability Index was a slightly higher estimate of intellectual ability than the Full Scale IQ (approximately 3 points higher than Full Scale IQ) and probably a more adequate measure to identify intellectual functioning in children with ADHD. Similar evidence was also found for children with specific learning disorder (Giofrè, Toffalini, Altoè, & Cornoldi, 2017; Moura et al., 2014; Poletti, 2016). For example, Giofrè et al. (2017) found that the Full Scale IQ–General Ability Index discrepancy represents an effective criterion for differentiating between children with and without specific learning disorder (AUC value of .762).

The examination of the most common WISC cognitive profiles linked to ADHD provided additional diagnostic information beyond the index scores- and subtest-level analyses. Some studies have found that the pattern of low scores on the subtests included in Freedom from Distractibility, ACID, SCAD, and the Bannatyne profiles is useful for diagnostic purposes (Hesapçioğlu et al., 2016; Mayes & Calhoun, 2004; Prifitera & Dersh, 1993; Snow & Sapp, 2000), but our results did not fully support their conclusion. Although the presence of the Bannatyne pattern and full or partial Freedom from Distractibility, ACID and SCAD profiles was more prevalent among children with ADHD, the sensitivity and specificity values revealed a low diagnostic accuracy. The most accurate cognitive profiles were the presence of the Freedom from Distractibility in the four lowest-scoring subtests and the Bannatyne pattern that were present in 27.6% and 22.4% of children with ADHD, respectively. Likewise, Filippatou and Livaniou (2005) through a stepwise discriminant function analysis found that the ACID profile did not efficiently identify children with ADHD from those without ADHD.

Based on these findings, we explored other approaches to (re)interpret the data from the most common WISC cognitive profiles. Through a ROC curve analysis and by applying the Youden index, we identified the optimal cutoff scores associated with the Freedom from Distractibility, ACID, and SCAD composite scores. To the best of our knowledge, the present study is the first to explore optimal cutoff scores of WISC-III in children with ADHD. The results obtained with this approach revealed greater diagnostic accuracy than the traditional full or partial profiles, which support our third hypothesis. For example, the Freedom from Distractibility showed the highest AUC value (= .781), and a score less than or equal to 17 correctly identified 49% of children with ADHD with a Full Scale IQ $\geq$ 80 (only 8.6% of false-positives). The Sequential Abilities revealed the second highest AUC value (= .770) and the sum of the age-adjusted-scaled scores of Digit Span, Coding, and Arithmetic subtests less than or equal to 27 correctly identified 49% of children with ADHD (11.1% of false-positives). The optimal cutoff scores for ACID and SCAD also showed adequate diagnostic accuracy.

Thus, optimal cutoff scores for WISC cognitive profiles may be another indicator to identify specific cognitive deficits and may be useful in the decision-making process relative to ADHD diagnosis. Obviously, WISC's cognitive profiles alone cannot be considered a diagnostic marker of ADHD (or of any other neurodevelopmental disorder) but may provide knowledge about the cognitive strengths and weaknesses that characterize this disorder. It would be of interest if future research could replicate these findings with larger samples of children with ADHD and analyze the diagnostic accuracy of optimal cutoff scores with the WISC-IV and -V.

Notwithstanding the relevance of the present study, there are some limitations that should be considered when interpreting the results. First, the Freedom from Distractibility Index was estimated by applying a linear equating method that was developed by Tellegen and Briggs (1967), which allowed the Freedom from Distractibility Index to be calculated based on the correlation between the Arithmetic and Digit Span subtests. In comparison to the Freedom from Distractibility Index scores based on the standardization sample (not available in the Portuguese version of WISC-III), this statistical technique underestimates scores in the upper portion of the distribution and overestimates scores in the lower portion of the distribution (the difference is approximately 2–3 points) (Raiford et al., 2008). Although the Tellegen and Briggs method is appropriate for use if the standardization data are not available (Flanagan & Kaufman, 2004; Raiford et al., 2008), the interpretation of this index score should be made with some caution. Second, the General Ability Index scores used in this study were obtained from the Prifitera et al. (1998) norms table because the Portuguese version of the WISC-III did not provide this index score. Thus, the interpretation of General Ability Index scores should also be made with some caution. Third, the ADHD group only included 98 children, which limits the generalizability of the findings. Fourth, although the children with ADHD did not receive psychostimulants during the week in which the evaluation was performed, it would be a better baseline comparison if all children with ADHD were medication naïve.

To conclude, children with ADHD revealed most pronounced deficits in the WISC-III subtests tapping working memory and processing speed, which consequently lower the Full Scale IQ. The General Ability Index may be a more adequate measure to identify intellectual functioning in children with ADHD. The Freedom from Distractibility was the index score/cognitive profile most impaired and that showed the highest diagnostic accuracy to discriminate children with and without ADHD. The optimal cutoff scores of the most common WISC cognitive profiles revealed greater diagnostic accuracy than the traditional approach of full or partial profiles. Although the information obtained from the WISC are of significant importance in the ADHD evaluation and decision-making process (Mayes & Calhoun, 2004; Prifitera et al., 1998; Schwean & Saklofske, 2005), it needs to be viewed in the context of a more comprehensive psychological assessment that includes a clinical interview, rating scales, observation of the child behavior, and cognitive measures (e.g., executive functions, attention, and working memory), among others.

Notes

1. Throughout the article the term “Freedom from Distractibility” will be used to refer to the composite measure of the sum of the age-adjusted-scaled scores of Arithmetic and Digit Span subtests (ranging from 2 to 38 points). In the case of the full and partial cognitive profile analysis, the “Freedom from Distractibility” will be also used to refer to a specific pattern of low age-adjusted-scaled scores on the Arithmetic and Digit Span subtests that were less than or equal to the scores on the remaining WISC-III subtests. The term “Freedom from Distractibility Index” will be used to refer to the WISC-III index score ($M = 100$ and $SD = 15$).

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Appendix

WISC-III mean scores for control group and ADHD subtypes.

	Control group ($n = 81$)	ADHD subtypes: ADHD-I ($n = 36$)	ADHD-HI ($n = 36$)	ADHD-C ($n = 26$)	Control group vs. ADHD subtypes: $F(3, 175)$	η^2_p	*post hoc* (Bonferroni)
IQs							
FSIQ	103.69 (10.05)	96.58 (11.18)	98.53 (11.99)	91.85 (6.79)	10.273***	.150	CG > ADHD-I, ADHD-C
VIQ	105.77 (10.24)	100.14 (11.58)	101.64 (11.22)	97.15 (9.23)	5.447**	.085	GC > ADHD-C
PIQ	101.52 (10.24)	95.17 (10.79)	97.58 (13.79)	89.88 (10.37)	8.016***	.121	GC > ADHD-I, ADHD-C; ADHD-HI > ADHD-C
Index Scores							
GAI	103.89 (8.50)	98.39 (8.50)	101.28 (10.84)	96.27 (6.00)	6.447***	.100	GC > ADHD-I, ADHD-C
VCI	105.20 (10.46)	100.86 (11.26)	102.53 (11.78)	97.85 (9.52)	3.561*	.058	GC > ADHD-C
POI	100.90 (10.01)	97.00 (10.65)	98.86 (14.24)	93.08 (10.49)	3.514*	.057	GC > ADHD-C
PSI	104.01 (13.76)	98.75 (14.65)	98.25 (11.67)	91.27 (14.01)	6.226***	.096	GC > ADHD-C
FDI	105.15 (9.93)	92.00 (12.14)	95.00 (12.00)	91.58 (12.17)	18.162***	.237	GC > ADHD-I, ADHD-HI, ADHD-C
Subtests							
Information	10.38 (2.07)	9.25 (2.62)	10.17 (2.79)	9.27 (1.90)	2.864*	.047	
Similarities	11.25 (2.44)	10.94 (2.69)	11.44 (2.95)	10.31 (1.91)	1.200	.020	
Arithmetic	11.01 (2.33)	9.22 (2.33)	9.69 (1.96)	8.73 (2.58)	5.303***	.139	GC > ADHD-I, ADHD-HI, ADHD-C
Vocabulary	10.78 (2.72)	9.69 (2.92)	9.22 (2.53)	9.65 (2.56)	3.464*	.056	GC > ADHD-HI
Comprehension	11.05 (2.45)	11.17 (2.90)	10.92 (2.70)	9.65 (2.48)	2.167	.036	
Digit Span	10.70 (2.29)	8.11 (2.53)	8.64 (3.02)	8.46 (1.72)	13.472***	.188	GC > ADHD-I, ADHD-HI, ADHD-C
Picture Completion	10.60 (2.34)	9.92 (2.72)	10.42 (3.28)	9.88 (2.12)	0.866	.015	
Coding	10.37 (2.66)	9.22 (3.09)	9.39 (2.53)	7.58 (3.03)	6.894***	.106	GC > ADHD-C
Picture Arrangement	10.51 (2.70)	9.86 (2.28)	9.56 (2.86)	9.35 (2.49)	1.908	.032	
Block Design	9.95 (2.12)	9.25 (2.11)	10.14 (2.69)	9.00 (2.48)	2.021	.033	
Object Assembly	10.22 (2.42)	9.17 (2.65)	9.58 (2.87)	8.04 (2.93)	4.833**	.077	GC > ADHD-C
Symbol Search	11.01 (2.96)	10.31 (2.93)	9.94 (3.07)	9.35 (2.72)	2.574	.042	
Discrepancies							
FSIQ – GAI	−0.20 (4.18)	−1.81 (8.45)	−2.75 (2.76)	−4.42 (3.92)	5.320**	.084	GC > ADHD-C
VIQ – PIQ	4.25 (10.78)	4.97 (13.08)	4.06 (14.14)	7.27 (16.09)	0.414	.007	

(*continued*)

Continued.

	Control group	ADHD subtypes			Control group vs. ADHD subtypes		
	($n = 81$)	ADHD-I ($n = 36$)	ADHD-HI ($n = 36$)	ADHD-C ($n = 26$)	F(3, 175)	η^2_p	*post hoc* (Bonferroni)
VCI – POI	4.30 (11.01)	3.86 (14.05)	3.67 (14.03)	4.77 (15.51)	0.046	.001	
VCI – PSI	1.19 (15.60)	2.11 (14.09)	4.28 (12.58)	6.58 (20.23)	0.937	.016	
VCI – FDI	0.05 (11.75)	8.86 (14.16)	7.53 (11.56)	6.27 (15.99)	5.377**	.084	GC > ADHD-I, ADHD-HI
POI – PSI	−3.11 (15.47)	−1.75 (14.63)	0.61 (15.09)	1.81 (17.14)	0.910	.015	
POI – FDI	−4.25 (11.32)	5.00 (13.37)	3.86 (16.70)	1.50 (14.87)	5.416**	.085	GC > ADHD-I, ADHD-HI
PSI – FDI	−1.14 (15.33)	6.75 (13.68)	3.25 (14.75)	−0.31 (16.26)	2.578	.042	
Cognitive Profiles *(composite scores)*							
FD	21.72 (3.31)	17.33 (4.05)	18.33 (4.00)	17.19 (4.06)	18.162***	.237	GC > ADHD-I, ADHD-HI, ADHD-C
ACID	42.47 (5.48)	35.81 (7.57)	37.89 (6.86)	34.04 (5.85)	17.073***	.226	GC > ADHD-I, ADHD-HI, ADHD-C
SCAD	43.10 (6.35)	36.86 (7.97)	37.67 (6.33)	34.12 (6.99)	15.688***	.212	GC > ADHD-I, ADHD-HI, ADHD-C
Spatial Abilities	30.78 (4.68)	28.33 (5.50)	30.14 (7.19)	26.92 (5.54)	3.968**	.064	GC > ADHD-C
Conceptual Abilities	33.07 (5.51)	31.81 (5.98)	31.58 (5.90)	29.62 (5.08)	2.616	.043	
Sequential Abilities	32.09 (4.43)	26.56 (5.84)	27.72 (5.02)	24.77 (5.47)	20.014***	.255	GC > ADHD-I, ADHD-HI, ADHD-C

Note. *$p < .05$. **$p < .01$. ***$p < .001$. IQ and Index Scores are composite IQs scores ($M = 100$ and $SD = 15$) and Subtests scores are age-adjusted-scaled scores ($M = 10$ and $SD = 3$). FSIQ = Full Scale IQ. VIQ = Verbal IQ. PIQ = Performance IQ. GAI = General Ability Index. VCI = Verbal Comprehension Index. POI = Perceptual Organization Index. PSI = Processing Speed Index. FDI = Freedom from Distractibility Index. FD = Freedom from Distractibility (the sum of the age-adjusted-scaled scores of Arithmetic and Digit Span subtests). CG = Control group. ADHD = Attention-Deficit/Hyperactivity Disorder. ADHD-I = Attention-Deficit/Hyperactivity Disorder predominantly inattentive. ADHD-HI = Attention-Deficit/Hyperactivity Disorder predominantly hyper-active/impulsive. ADHD-C = Attention-Deficit/Hyperactivity Disorder combined. Standard deviations in parentheses.