

Validity of proposed DSM-5 ADHD impulsivity symptoms in children

Gül Ünsel Bolat¹ · Eyüp Sabri Ercan¹ · Giovanni Abrahão Salum^{2,3} · Öznur Bilaç⁴ · Rafael Massuti² · Taciser Uysal Özasan⁵ · Hilmi Bolat⁶ · Luis Augusto Rohde^{2,3}

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Abstract The American Psychiatric Association (APA) working group on Attention-Deficit/Hyperactivity Disorder (ADHD) proposed the inclusion of four new impulsivity symptoms. However, they were not included in DSM-5 due to the lack of sufficient evidence. The aim of this study is to investigate the performance of the proposed four ADHD impulsivity symptoms with respect to: (a) ADHD factor structure; (b) performance in predicting clinical impairment; (c) specificity for ADHD diagnosis and (d) best symptomatic threshold to predict clinical impairment. The sample comprised 416 children (31 ADHD subjects according to both DSM-IV and proposed DSM-5, 20 ADHD subjects according to just one diagnostic system and 365 controls) from 12 schools. Diagnoses were derived using semi-structured interviews and ADHD rating scales. Results from confirmatory factor analysis indicate that addition of the four new impulsivity items provided a slightly better factor structure if compared to models including only 18 items. Regression analyses showed that

only one of the new impulsivity symptoms (impatient) was part of the list of best predictors of impairment. None of the four new impulsivity items was specifically associated with ADHD diagnosis. The best cutoff point in the hyperactivity/impulsivity dimension for predicting impairment did not change significantly. Overall, our findings suggest that the determination on how to best capture impulsivity dimension as part of the ADHD construct needs more investigation and that there is not enough evidence to include these four assessed impulsivity symptoms as part of the ADHD criteria.

Keywords DSM-5 · ADHD · Confirmatory factor analysis · Impulsivity

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most common mental disorders of childhood, with an estimated prevalence around 3–5 % in school-aged children [1, 2]. The disorder leads to significant academic, social, and health problems with lifelong negative effects [3]. However, major questions remain concerning the best set of criteria used to diagnose ADHD.

The working group (WG) on ADHD from the American Psychiatric Association (APA) proposed some changes to the criteria for ADHD in children and adolescents in 2010 [4, 5]. Some of them were implemented in the final DSM-5 text whereas others were not [6]. Modifications implemented included the change in age of onset from 7 to 12 years and the deletion of Autistic Spectrum Disorders as an exclusionary criterion for performing an ADHD diagnosis. In addition, the relevance of impairment as part of the ADHD criteria was deemphasized. For instance,

✉ Gül Ünsel Bolat
gul.unsel.bolat@gmail.com

¹ Department of Child and Adolescent Psychiatry, Faculty of Medicine, Ege University, Izmir, Turkey

² ADHD Outpatient Program, Department of Psychiatry, Hospital de Clinicas de Porto Alegre, Federal University of Rio Grande do Sul, Porto Alegre, Brazil

³ National Institute of Developmental Psychiatry for Children and Adolescents, Sao Paulo, Brazil

⁴ Department of Child and Adolescent Psychiatry, Manisa Mental Health Hospital, Manisa, Turkey

⁵ Isparta Maternity and Children Hospital, Isparta, Turkey

⁶ Department of Medical Genetics, Faculty of Medicine, Ege University, Izmir, Turkey

impairment from symptoms in two settings was a requirement in DSM-IV, whereas DSM-5 requires only the presence of ADHD symptoms in two or more settings. The potential inclusion of four new impulsivity items is among the non-implemented changes. They were not included due to the lack of sufficient evidence of their validity and clinical utility.

Nevertheless, two decades ago, Wender proposed that emotional impulsivity was one of the core clusters of adult ADHD [7]. Since then, several investigations assessed the role of impulsivity in ADHD phenotype across the life span. For instance, Barkley [8] reported that emotional impulsiveness is a significant part of ADHD in the life with the disorder, particularly in adults, determining impairment in home functioning, social interactions, community activities, dating/marital relations, money management, driving, and leisure/recreational activities beyond impairment due to inattention and hyperactivity. Moreover, emotional impulsiveness was the second greatest contributor to an omnibus impairment index just after severity of inattention [8].

Despite that, very few studies investigated the contribution of this new set of impulsivity items to ADHD diagnosis. A previous study detected no consistent pattern of association with either ADHD diagnosis or with clinical impairment for the four new impulsivity symptoms as proposed by DSM-5 WG on ADHD in adults [9]. Another previous study reported that the new four impulsivity symptoms had a low specificity for ADHD diagnosis in children [10]. Apart from these studies, we are not aware of other previous studies assessing the performance of including new impulsivity items to the DSM-IV ADHD criteria in children.

In this study, we aimed to evaluate the validity of the DSM-5 WG ADHD criteria in a sample of children from Izmir, Turkey. Our main objective is to test if the four additional ADHD impulsivity symptoms, as proposed by DSM-5 WG on ADHD, add value to the ADHD diagnosis using psychometric analysis and associations with functional impairment. We hypothesize that the inclusion of new four impulsivity items in ADHD criterion will add clinically relevant information to the diagnosis of ADHD and differential diagnosis of ADHD with other mental disorders.

Methods

Sample

Sampling procedures were fully described previously [11]. The data of this study derived from an existing database collected to determine the prevalence rate of ADHD in a school

sample of elementary school children [11]. Briefly, the sample was collected in the central district of Izmir, Turkey. The city has a population of around 405,580 individuals and had 66 elementary schools up to the 5th grade in 2011. The age range of the subjects was 6–14 years. These schools included an approximate number of 27,080 students at that year. A total of 12 schools were chosen, after randomization procedures stratified by socioeconomic status of the families attending these schools (low/middle/high), according to the Ministry of National Education. Out of the 12 selected schools, a random sample of 419 subjects was included in this study. This sample size was estimated considering a 5 % margin of error, alpha equal to 1 %, and assuming general psychiatric disorders prevalence rate around 20 %. Parent gave their written informed consents. The Ege University Ethical Committee approved the study protocol.

Our previous studies pointed that ADHD might be more prevalent in the Turkish population. The immigrant origins of Turkish population and the relation between migration and DRD4 gene (one of the most important candidate genes in ADHD etiology) could explain this high ADHD prevalence in Turkish children. When we look at the immigration rate of İzmir, where this study has done, we saw that İzmir is in the third place in Turkey according to letting in immigrants which may support our hypothesis [11–13].

Symptomatic assessment

Parents and teachers fulfilled Turkish version of Attention-Deficit/Hyperactivity Disorder Rating Scale-IV (ADHD-RS-IV) and also data on the four additional impulsivity items, as proposed by the DSM-5 on ADHD. The ADHD-RS-IV was translated and adapted into Turkish by Ercan et al. [14]. The ADHD-RS-IV [15] is an 18-item questionnaire based on the diagnostic criteria for ADHD as described in the 4th edition of the Diagnostic and Statistical Manual of Mental Disorders of the American Psychiatric Association [16]. The symptoms were scored by assigning a severity estimate for each symptom on a 4-point Likert-type scale (0 = not at all; 1 = just a little; 2 = much; and 3 = very much). Ratings of “much” and “very much” for each item were considered positive, as done in other similar investigations [17, 18]. The ADHD-RS-IV has shown adequate criterion validity and good reliability in different cultures both for parent and teacher reports [15, 19]. The four additional items were: (a) acts without thinking; (b) impatient; (c) uncomfortable doing things slowly; (d) difficulty to resist temptations. These items were assessed as additional items in the ADHD-RS-IV using the same Likert-scale format for answering. For these four items, translation and back translation procedures were applied to capture the same ideas as the original wording. All of 22 items were fulfilled under supervision.

Diagnostic procedures

The evaluation of other psychiatric disorders except diagnosis of ADHD was performed using the K-SADS-PL (Schedule for Affective Disorders and Schizophrenia for School-Age Children Present and Lifetime Version). The K-SADS-PL is a highly reliable semi-structured interview for the assessment of a wide range of psychiatric disorders [20], with documented reliability and validity for Turkish culture [21]. A trained child and adolescent psychiatry resident applied the instrument, first with the primary caretaker and then with the child, separately. The training for K-SADS-PL administration is given only by “The Turkish Association of Child and Adolescent Psychiatry” providing a uniform and efficient training for the participants.

For ADHD diagnosis, we performed a combination of symptomatic assessment provided by ADHD rating scales (as described below) and a detailed interview by another child and adolescent psychiatrist with both parents and teachers to determine impairment with a semi-structured instrument. In this interview, parents provided impairment information about 4 areas of general functioning of the child: the child’s relationships with his/her sibling(s), relationships with friends, ability to do his/her homework, and general adjustment at home. The interviewer evaluated the 4 domains of impairment also with teachers using a different scale from parents: whether the patient was considered problematic, his/her relations with friends at school, his/her general success in subjects and lastly the self-esteem level of the children. All items were rated as no problem at all (score = 0), a little problematic (score = 1), and very problematic (score = 2). Children with a score of at least 2 points (range 0 to 8) were considered as having significant impairment (e.g., threshold of score of 2 in one area, or 1 in two areas). This procedure was used previously in same population and other populations [11, 12, 22, 23]. And, child and adolescent psychiatrists who performed K-SADS and semi-structured instrument of impairment were blind to the results of other interviews.

We considered a positive ADHD diagnosis according to the DSM-IV if the following condition was fulfilled: (1) either parent or teacher endorsed at least 6 of 9 inattention or hyperactivity/impulsivity symptoms with a score of 2 or higher (DSM-IV criterion A); and (2) a score of at least 2 in the scales assessing impairment both at home (parent report) and at school (teacher report) (DSM-IV ADHD criterion C; presence of impairment in two settings). As almost all of our subjects were younger than 12 years of age (97 %) and previous reports suggest that age-of-onset of impairment before 7 years is not a valid and reliable criterion for ADHD [24, 25], we did not assess this criterion for the purposes of this study.

In making ADHD diagnosis according to DSM-5 as initially proposed by DSM5-WG, the following conditions were required: (1) either parents or teachers endorsed at least 6 of 9 inattention (which is the same for DSM-IV) or 9 of 13 hyperactivity/impulsivity symptoms with a score of 2 or higher (criterion A); (2) the presence of at least 3 positive symptoms in any dimension by a different source of information (e.g., if parents endorsed sufficient symptoms in inattentive and/or hyperactive/impulsive dimension, we requested at least 3 symptoms to be endorsed by teachers in any of the two dimensions); (3) a score of at least 2 in the scales assessing impairment either at home (parents report) or at school (teachers report) (DSM-5 ADHD criterion D; interference of symptoms in functioning).

The decision of requiring at least 9 from 13 items was chosen in order to preserve the rate of symptoms needed to be endorsed in the hyperactivity/impulsivity dimension (6/9 represent 67 % in DSM-IV; and 9/13 represent 69 % for DSM-5WG proposal). The decision to require symptom endorsement from different sources of information was done to assure that the DSM-5 criterion requesting presence of several symptoms in at least two settings was fulfilled. Given that the majority of our subjects (97 %) were younger than 12 years of age, we did not assess age of onset criterion.

Data analysis

To evaluate the change in clinical and demographic profiles with DSM-5 WG criteria, we made a comparison among three groups; (1) agreement group (fulfilling diagnosis of both DSM-IV and proposed DSM-5 criteria), (2) disagreement group (fulfilling diagnosis of either DSM-IV or proposed DSM-5) and (3) controls. These independent groups were compared using the Chi square test for categorical variables and the ANOVA for quantitative variables.

Confirmatory factor analysis

The factor structure of the ADHD symptoms was tested with confirmatory factor analysis (CFA) using unidimensional, correlated (with 2 and 3 correlated dimensions) and bifactor models (with 1 general factor and 2 and 3 specific factors). This analysis was performed independently for parents and teachers and using the 18 DSM-IV symptoms as well as the 22 DSM-5 symptoms according to ADHD-RS-IV scale. This strategy examines whether the factor structure would change with the addition of the four new symptoms and whether a three-factor solution (with impulsivity emerging as a separate factor from hyperactivity) has a better fit when the four new symptoms are included in the model. Competing models were compared using the following goodness of fit indexes: root mean square error of

approximation (RMSEA), the comparative fit index (CFI), and the Tucker Lewis Index (TLI). The model was considered reliable when $RMSEA < 0.06$, CFI and TLI ≥ 0.95 [26].

CFA parameters of factor loadings and category thresholds for the best fitting models were also examined. Factor loadings and category thresholds reflect how well the item discriminates different severity levels or represent the strength of the relationship between latent trait and item responses. Item category thresholds indicate the severity level at which there is a 50 % probability of endorsing a given category or higher. The mean of the thresholds for each item was computed as the item location on the severity continuum.

Model reliability was assessed using the following indexes: (a) Lucke's omega (ω), a model-based reliability estimate for all models, being analogous to alpha coefficient; (b) the hierarchical omega coefficient (ω_h), which judges the degree to which composite scale scores are interpretable as a measure of a single common factor; and (c) the omega subscale (ω_s) reliability estimate for a residualized subscale, an index that controls for that part of the reliability due to the general factor (i.e., showing what would the reliability of subscale score be if the effects of the general factor were removed). Values of ω , ω_h and ω_s coefficients may vary between 0 and 1, where higher scores indicate greater reliability; a value of 1 indicates that the instrument's sum score measures the target construct with perfect accuracy.

Associations with impairment

The performance of the DSM-5 WG ADHD symptoms in predicting impairment was tested in a three-step approach. In these steps, we created an impairment variable according to both parents and teachers. The report of parents or teachers was enough to accept impairment as positive. First, bivariate associations between individual symptoms and impairment were assessed using Pearson Chi Square and quantified with odds ratios estimates (unadjusted estimated). The association between DSM-5 symptoms and other psychiatric disorders was also tested. Thus, for each DSM-5 item, the odds ratios of the associations with ADHD and with comorbidity could be compared. Second, a multiple stepwise logistic regression model with forward entrance (entry criteria $p < 0.1$; removal criteria $p < 0.05$) was performed, considering impairment as the dependent variable and all DSM-5 WG ADHD symptoms as independent variables. This analysis allowed us to find how many and which DSM-5 WG symptoms are independently associated with impairment after controlling for the other DSM-5 WG symptoms and defines how many symptoms are required to capture all the variance on associated

symptom impairment (which will be used for further APS regression). In the third step, all possible subsets (APS) logistic regression analysis was used to investigate the set of DSM-5 symptoms that best predicted impairment. The APS analysis helps to select the best subset from a larger set of predictors. In such situations, different subsets might have almost equivalent associations with the outcome, and conventional stepwise regression analysis might select a suboptimal subset owing to minor differences in bivariate associations. The APS analysis protects against this problem because it generates results for a large number of different models with a fixed number of predictors, which was determined from the earlier stepwise logistic regression analysis (described above). The APS analysis also ranks the best subsets according to their association with the outcome (using the Chi square as the ranking criterion). Once the ranking of subsets is known, the researcher can select the predictors that are more consistent across the top-ranked subsets. The analytic procedure described here was similar to the one used by our group in previous studies [9].

Finally, receiver-operating characteristic (ROC) curves were built for testing the best cutoff (best balance between sensitivity and specificity) for the number of DSM-5 working group ADHD symptoms to predict clinical impairment (considering the above-described DSM-5 impairment cutoff). The determination of the best cutoffs for predicting impairment was done separately for DSM-5 inattention and hyperactivity/impulsivity symptoms. These models all assumed equal weighting of false-positive and false-negative errors in selecting the optimal cut point.

For all analyses, a 5 % significance level for a two-tailed test was adopted. CFA analyses were conducted in M-Plus (version 7.31). All possible subsets regressions were performed in R-project software (package 'leaps'). Receiver Operator Analysis was conducted in Signal Detection Software ROC4.

Results

Clinical and demographic profile among the DSM-defined groups

Our sample comprised 419 children and their parents. Almost all subjects ($n = 416$) completed the entire diagnostic procedures. A group of 31 subjects fulfilled both DSM-IV and proposed DSM-5 ADHD criteria (agreement group), 20 subjects fulfilled ADHD diagnosis according to just one diagnostic system (disagreement group) and 365 subjects were defined as controls (not fulfilled diagnostic criteria for any of the algorithms). Regarding the disagreement group, the main reasons for fulfilling ADHD diagnosis according to just one of the two criteria (DSM-IV

Table 1 Socio-demographics and comorbidity profile of DSM-5ADHD cases and subjects without ADHD ($n = 416$)

	Control (C)	Agreement (A)	Disagreement (DA)	<i>p</i> value	Group comparison
<i>N</i> (%)	365 (%87)	31 (%7)	20 (%4)		
Age	9.1 ± 1.5	9.3 ± 1.4	9.5 ± 1.3	0.522	
Gender (%)				0.012	DA > C
Male	187 (51.2)	21 (67.7)	16 (80)		
Education (%)				0.27	
Kinder garden	4 (1.1)	4 (12.9)	1 (5)		
First grade	70 (19.2)	6 (19.4)	2 (10)		
Second grade	74 (20.3)	4 (12.9)	4 (20)		
Third grade	73 (20)	5 (16.1)	5 (25)		
Fourth grade	71 (19.5)	7 (22.6)	4 (20)		
Fifth grade	73 (20)	5 (16.1)	4 (20)		
Marital status (%)				0.031	C&DA < A
Divorced	38 (10.4)	7 (22.6)	0		
Mother age (mean ± SD)	35.2 ± 5.6	35.2 ± 6.7	36.4 ± 7.2	0.681	
Mother education				<0.001	C\DA&A
No	46 (12.6)	8 (25.8)	8 (40)		
Elementary	181 (49.7)	17 (54.8)	10 (50)		
Secondary	29 (8)	3 (9.7)	1 (5)		
High School	70 (19.2)	2 (6.5)	0		
University	38 (10.4)	1 (3.2)	1 (5)		
Father age (mean ± SD)	40 + 6.4	40.3 + 7.8	42.1 + 9.2	0.408	
Father education (%)				0.002	C/DA&A
No	20 (5.5)	4 (12.9)	2 (10)		
Elementary	159 (43.6)	19 (61.3)	13 (65)		
Secondary	40 (11)	3 (9.7)	1 (5)		
High School	94 (25.8)	4 (12.9)	3 (15)		
University	52 (14.2)	1 (3.2)	1 (5)		
Comorbidities (%)					
Oppositional defiant disorder	4 (1.1)	3 (9.7)	2 (10)	<0.001	C < DA&A
Conduct disorder	1 (0.3)	5 (16.1)	2 (10)	<0.001	C < DA&A
Mood disorder	10 (2.7)	2 (6.5)	0	0.363	
Anxiety	50 (13.7)	7 (22.6)	0	0.073	
Mental retardation	9 (2.5)	4 (12.9)	2 (10)	0.021	C < DA&A

Data are presented as the means ± standard deviations or *n* (%), as appropriate

Bold values mark statistically significant differences

and DSM-5 WG criteria) were: (a) DSM-5 requires only the presence of ADHD symptoms in two or more settings ($n = 8$), impairment in two settings is necessary for DSM-IV ADHD diagnosis ($n = 9$) and (b) three subjects fulfilled DSM-IV criteria for 6/9 hyperactive/impulsive symptoms but did not fulfill the DSM-5 WG requirement of 9/13 symptoms.

We were not able to show any significant differences in most of the socio-demographic characteristics between agreement and disagreement groups (except for marital status, $p = 0.031$, see Table 1). When we compared comorbidity rates among the three groups, there was no significant

difference between agreement and disagreement groups (all p values >0.05).

Factor Structure of 18 symptoms by DSM-IV and 22 symptoms by proposed DSM-5

The CFA for both the 18 symptoms of DSM-IV and the proposed 22 symptoms of DSM-5 were performed to evaluate the fit of the following models: (1) one-factor (ADHD); (2) correlated two-factor (inattention and hyperactivity-impulsivity); (3) correlated three-factor (inattention, hyperactivity, impulsivity); (4) bifactor model with

one general and two specific factors (inattention and hyperactivity-impulsivity); and (5) bifactor model with one general and three specific factors (inattention, hyperactivity, and impulsivity).

For both parents and teachers, according to both DSM-IV and DSM-5 solutions, the bifactor model with a general factor and three specific factors had the best fit to the data if compared to the other models (see Supplemental material). Table 2 presents data on confirmatory factor analysis for both parent and teacher data using the best model with 22 symptoms. In this bifactor model with one general and three specific factors (inattention, hyperactivity and impulsivity), most of the items exhibited higher factor loadings on the general factor than the inattention, hyperactivity and impulsivity specific factors for both parent and teacher reports. Only the general factor presented high reliability ($\omega_h = 0.975, 0.990$; parents and teachers respectively). Specific inattention ($\omega_s = 0.049$ and 0.101 ; parents and teachers respectively), hyperactivity ($\omega_s = 0.010$ same for parents and teachers) and impulsivity factors ($\omega_s = 0.017$ and 0.018 ; parents and teachers, respectively) explained very little of the residual variance, meaning that when the effects of the general factor were removed, we detected lower reliability indexes for specific factors.

An item-level inspection of the size of the factor loadings on specific factors revealed that factor loadings for the new proposed four impulsivity items were higher than the current impulsivity symptoms, which indicates they are slightly better at informing on impulsivity specifically if compared to current items. Nevertheless, the new four items (as well as the current items) loaded more strongly on the ADHD general factor than on the impulsivity specific characteristics, as revealed by stronger factor loadings on the general factor if compared to the specific impulsivity factor. An inspection of the item category thresholds also revealed that the new items are slightly better at discriminating subjects at the severe end of the ADHD latent trait, particularly the item 'Difficulty to resist temptations'.

DSM-5 proposed symptom performance in predicting clinical impairment

Tables 3 and 4 present results for the regression analyses of the 22 DSM-5 symptoms in predicting clinical impairment according to parents and teachers. In the first step, the following items were detected as the best 10 symptoms according to parental reports using univariate tests (according to unadjusted odds ratio ranking): difficulty to resist temptations, acts without thinking, uncomfortable doing things slowly, impatient, difficulty sustaining attention, fails to give close attention to details, reluctant to engage in mental tasks, does not follow through, loses objects and forgetful. It is important to note that the best four of these

items were the proposed new impulsivity items followed by six inattentive symptoms (see Table 3). Moreover, the ten best symptoms for teachers' report comprised again the four new proposed impulsivity items and six inattention items and most of them are similar with those derived from parent reports (See Table 4).

In the second step, the stepwise logistic regression analysis showed that six symptoms and five symptoms for parents and teachers, respectively, are capable of capturing all symptom-associated variance on ADHD-related impairment (adjusted $R^2 = 0.396$ and 0.388 , respectively). Both of these results included one of the proposed new impulsivity symptoms (impatient) as an independent predictor of impairment (see Table 3).

In the third step, using APS regression we analyzed most recurrent symptoms that predict impairment among the ten top-ranked subsets of six symptoms for parents and five symptoms for teachers. In this step, we reached three symptoms for parents and two symptoms for teachers that appear in all subsets among 22 items proposed by DSM-5 WG. These most recurrent items include one of the four proposed impulsivity symptoms "impatient" according to both information sources (see Tables 3, 4)

DSM-5 proposed symptom performance in predicting DSM-5 WG ADHD diagnosis and comorbidities

Tables 3 and 4 also display results for the proposed 22 symptoms performance according to both parents and teachers in predicting DSM-5 WG ADHD diagnosis and the following comorbidities: Oppositional Defiant Disorder (ODD), Conduct disorder (CD), Mood Disorder (MD), and Anxiety Disorder (AD). In univariate analyses using parents' data, all of four new impulsivity items were significantly associated to ADHD, 'Acts without thinking' and 'Impatient' with ODD, 'Acts without thinking', 'Impatient' and 'Uncomfortable doing things slowly' with CD, all of four new impulsivity items with Mood Disorder and 'Impatient', 'Uncomfortable doing things slowly' and 'Difficulty to resist temptations' with AD. In univariate analyses using teachers' data, all of four new impulsivity items were significantly associated to ADHD, 'Acts without thinking' and 'Impatient' with ODD, 'Acts without thinking', 'Impatient' and 'Difficulty to resist temptations' with CD, none of four new impulsivity items with Mood Disorder and AD. None of the four new impulsivity items was specifically associated with ADHD diagnosis according to both parents and teachers.

Best cutoff of ADHD symptoms to predict impairment

The general performance in predicting clinical impairment was very similar using all 22 DSM-5 WG symptoms

Table 2 Confirmatory factor analysis fit indexes for attention-deficit/hyperactivity disorder (proposed DSM5)

Items	According to PARENTS, with $n = 22$ symptoms										According to TEACHERS, with $n = 22$ symptoms									
	Bifactor model—three-factors (λ)					Category thresholds					Bifactor model—three-factors (λ)					Category thresholds				
	G	Ina	H	Imp	$\bar{T}x$	T1	T2	T3	T \bar{x}	T \bar{x}	G	Ina	H	Imp	$\bar{T}x$	T1	T2	T3	T \bar{x}	T \bar{x}
Fails to give close attention to details	.651	.521			.840	-.160	1.084	1.597	.840	.624	.709			.703	-.036	.736	1.410	1.410	.703	.703
Difficulty sustaining attention	.701	.454			1.312	.546	1.411	1.978	1.312	.642	.682			1.024	.262	1.041	1.769	1.769	1.024	1.024
Does not seem to listen	.699	.212			1.042	.308	1.200	1.619	1.042	.629	.509			1.290	.572	1.276	2.021	2.021	1.290	1.290
Does not follow through	.637	.534			1.167	.411	1.291	1.799	1.167	.669	.689			.950	.275	.980	1.596	1.596	.950	.950
Difficulty organizing tasks	.644	.535			1.247	.444	1.319	1.978	1.247	.645	.716			.980	.293	.933	1.714	1.714	.980	.980
Reluctant to engage in mental tasks	.683	.523			.912	.258	.982	1.497	.912	.671	.681			.844	.219	.852	1.460	1.460	.844	.844
Loses objects	.687	.260			1.005	.359	1.140	1.516	1.005	.683	.517			1.206	.572	1.249	1.798	1.798	1.206	1.206
Easily distracted	.764	.335			.668	-.021	.707	1.319	.668	.679	.655			.814	.091	.835	1.515	1.515	.814	.814
Forgetful	.708	.322			1.041	.290	1.117	1.715	1.041	.655	.644			1.010	.306	1.010	1.714	1.714	1.010	1.010
Fidgets	.721	.546			.614	-.111	.676	1.277	.614	.882	.371			1.068	.415	1.150	1.640	1.640	1.068	1.068
Gets up	.848	.360			1.093	.464	1.175	1.641	1.093	.876	.403			1.139	.530	1.198	1.688	1.688	1.139	1.139
Runs about	.849	.230			1.294	.707	1.238	1.937	1.294	.840	.410			1.335	.861	1.347	1.798	1.798	1.335	1.335
Excessively Loud	.789	.105			1.296	.546	1.319	2.022	1.296	.927	.159			1.319	.682	1.378	1.898	1.898	1.319	1.319
On the go	.807	.370			.846	.265	.925	1.349	.846	.868	.436			1.348	.818	1.362	1.863	1.863	1.348	1.348
Talks excessively	.781			-.046	.567	-.240	.754	1.188	.567	.906		.204		.991	.306	.980	1.688	1.688	.991	.991
Blurts out answers	.743			.021	.835	.093	.916	1.497	.835	.880		.216		1.242	.558	1.304	1.863	1.863	1.242	1.242
Difficulty waiting his turn	.779			.126	1.050	.283	1.152	1.715	1.050	.964		.196		1.228	.551	1.236	1.898	1.898	1.228	1.228
Interrupts or intrudes	.800			-.047	.986	.265	1.095	1.597	.986	.942		.145		1.222	.593	1.276	1.798	1.798	1.222	1.222
Acts without thinking	.762			.401	1.338	.451	1.305	2.257	1.338	.840		.344		1.268	.579	1.290	1.936	1.936	1.268	1.268
Impatient	.659			.697	.856	.021	.907	1.641	.856	.840		.445		1.306	.530	1.318	2.070	2.070	1.306	1.306
Uncomfortable doing things slowly	.644			.621	1.125	.359	1.152	1.864	1.125	.794		.464		1.450	.682	1.410	2.257	2.257	1.450	1.450
Difficulty to resist temptations	.712			.375	1.861	1.304	1.831	2.447	1.861	.774		.349		1.731	1.139	1.714	2.341	2.341	1.731	1.731
ECV (%)																				
ω	.977	.976,975		.975						.991	.991,990		.990							
ω_h	.975									.990										
ω subscale		.049,010		.017							.101,010		.018							
CFI	.987									.992										
TLI	.984									.990										
FP	110									72										
RMSEA	.046									.063										

Uni unidimensional, *HI* hyperactivity-impulsivity, *Ina* inattention, *Imp* impulsivity, *G* general, λ factor loadings, *ECV* explained common variance, ω omega coefficient, ω_h omega hierarchical, *CFI* comparative fit index, *TLI* Tucker–Lewis index, *FP* free parameters, *RMSEA* root mean square error of approximation

Table 3 Proposed DSM-5 symptom performance in predicting impairment, DSM-5 ADHD diagnosis, and comorbidities (parents)

DSM-5 symptom	Symptom versus impairment						DSM-5		ODD		Conduct Disorder		Mood Disorder		Anxiety	
	Univariate			Stepwise			Univariate		Univariate		Univariate		Univariate		Univariate	
	OR	CI 95 %	OR	CI 95 %	OR	CI 95 %	OR	CI 95 %	OR	CI 95 %	OR	CI 95 %	OR	CI 95 %	OR	CI 95 %
1 Fails to give close attention to details	10.1 (6)	5.0–20.4	2.5	1.0–6.3	8	8.9 (18)	4.4–18.0	6.6 (7)	1.8–23.8	3.8 (12)	0.8–16.6	2.1 (16)	0.5–8.0	1.5 (9)	0.8–3.2	
2 Difficulty sustaining attention	11.6 (5)	4.3–30.7			0	19.7 (4)	8.7–44.3	13.5 (2)	3.6–49.5	1.6 (19)	0.2–14.1	1.0 (21)	0.1–8.4	0.0 (2)	1.4–6.8	
3 Does not seem to listen	6.4 (14)	3.2–12.8			0	10.8 (13)	5.2–22.4	5.5 (9)	1.4–20.2	4.8 (7)	1.1–20.9	6.0 (3)	1.8–19.7	0.8 (20)	0.3–2.3	
4 Does not follow through	8.8 (8)	3.9–19.6			2	19.7 (5)	9.1–42.4	6.6 (8)	1.8–24.6	5.8 (6)	1.3–25.4	0.8 (22)	0.1–6.5	0.8 (20)	0.3–2.3	
5 Difficulty organizing tasks	6.9 (12)	3.1–15.0			0	25.8 (2)	11.7–57.0	7.0 (5)	1.9–26.3	6.2 (4)	1.4–27.0	3.4 (6)	0.8–13.1	0.9 (19)	0.3–2.4	
6 Reluctant to engage in “mental” tasks	9.7 (7)	5.1–18.3	4.2	1.8–10.0	10	31.6 (1)	13.9–71.5	5.4 (10)	1.5–19.4	9.1 (2)	2.1–39.2	2.6 (8)	0.7–9.1	1.5 (8)	0.8–3.2	
7 Loses objects	8.7 (9)	4.3–17.5			5	15.6 (7)	7.5–32.4	4.8 (14)	1.3–17.8	2.3 (15)	0.4–11.9	2.3 (10)	0.6–9.0	1.3 (14)	0.6–2.9	
8 Easily distracted	4.5 (18)	2.8–7.3			0	8.6 (19)	4.2–17.5	4.9 (12)	1.3–18.0	0.4 (21)	0.0–3.6	2.3 (12)	0.7–7.5	1.3 (12)	0.7–2.6	
9 Forgetful	8.2 (10)	4.1–16.1	2.8	1.1–6.7	4	11.1 (12)	5.4–22.7	4.6 (16)	1.2–17.0	2.2 (16)	0.4–11.3	2.2 (13)	0.5–8.6	1.9 (5)	0.9–3.9	
10 Fidgets	2.8 (21)	1.8–4.5	0.3	0.1–0.7	10	9.2 (17)	4.4–19.0	3.1 (21)	0.8–10.9	1.8 (17)	0.4–7.7	2.2 (14)	0.6–7.1	0.9 (17)	0.5–1.8	
11 Gets up	6.9 (11)	3.4–13.7			3	20.2 (3)	9.5–42.7	5.2 (11)	1.4–19.2	2.5 (14)	0.4–12.7	2.5 (9)	0.6–9.7	1.4 (10)	0.7–3.1	
12 Runs about	6.5 (13)	3.2–13.4			1	14.0 (8)	6.7–29.5	3.7 (18)	0.9–14.9	15.3 (1)	3.5–66.7	2.8 (7)	0.7–11.0	1.3 (11)	0.6–3.2	
13 Excessively loud	6.9 (12)	3.1–15.0			0	13.8 (9)	6.4–29.7	4.4 (17)	1.0–17.8	6.2 (4)	1.4–27.0	1.9 (17)	0.4–9.4	1.6 (6)	0.7–3.9	
14 On the go	6.1 (15)	3.5–10.6	2.5	1.0–6.0	7	19.4 (6)	9.0–41.6	4.8 (13)	1.3–17.3	2.8 (13)	0.6–12.2	1.5 (19)	0.4–5.9	1.1 (17)	0.5–2.2	
15 Talks excessively	3.0 (20)	1.9–4.8			0	9.61 (16)	4.7–19.5	14.9 (1)	3.1–71.5	1.1 (20)	0.2–5.7	1.7 (18)	0.5–5.9	1.2 (15)	0.7–2.3	
16 Blurts out answers	3.4 (19)	2.0–5.8			0	8.4 (20)	4.2–16.8	7.3 (4)	2.0–26.7	1.5 (18)	0.3–7.7	2.3 (11)	0.6–8.0	1.2 (16)	0.6–2.4	
17 Difficulty waiting his turn	5.2 (17)	2.7–10.0			0	16.2 (7)	7.8–33.7	3.1 (20)	0.7–12.5	7.5 (3)	1.8–31.0	1.4 (20)	0.3–6.6	1.3 (13)	0.6–2.9	
18 Interrupts or intrudes	5.6 (16)	3.0–10.5			0	13.6 (10)	6.6–28.0	10.4 (3)	2.8–38.3	3.9 (11)	0.9–16.9	2.1 (15)	0.5–8.2	0.6 (21)	0.3–1.7	
19 Acts without thinking	20.0 (2)	6.9–57.4			0	7.2 (21)	3.3–15.5	6.8 (6)	1.8–25.4	6.0 (5)	1.3–26.2	5.1 (4)	1.4–17.8	1.6 (7)	0.7–3.7	
20 Impatient	15.1 (4)	7.7–29.2	10.4	4.7–23.0	10	10.6 (14)	5.2–21.5	4.7 (15)	1.3–16.7	4.6 (8)	1.1–19.1	6.8 (2)	2.1–22.1	1.2 (3)	1.1–4.0	
21 Uncomfortable doing things slowly	15.2 (3)	6.6–34.9			0	16.2 (6)	7.8–33.7	1.7 (22)	0.3–8.6	4.4 (9)	1.0–19.0	3.7 (5)	1.0–12.8	0.4 (4)	1.0–4.3	
22 Difficulty to resist temptations	26.4 (1)	3.4–203.5			0	9.7 (15)	3.3–28.6	3.3 (19)	0.3–28.5	4.3 (10)	0.4–37.9	11.9 (1)	2.8–50.2	3.6 (1)	1.2–11.4	

Regression values are shown as adjusted odds ratios with 95 % confidence intervals. APS regression is shown as the number of appearances among the 10 top-ranked six-item subsets
OR odds ratio, CI confidence interval

Table 4 Proposed DSM-5 symptom performance in predicting impairment, DSM- 5 ADHD diagnosis, and comorbidities (Teachers)

DSM-5 symptom	Symptom versus impairment						DSM-5		ODD		Conduct Disorder		Mood Disorder		Anxiety	
	Univariate			Stepwise			Univariate		OR	CI 95 %	OR	CI 95 %	OR	CI 95 %	OR	CI 95 %
	OR	CI 95 %	OR	CI 95 %	OR	CI 95 %	OR	CI 95 %								
1 Fails to give close attention to details	9.6 (7)	5.6–16.5	5.4	2.7–10.6	16.4 (8)	7.4–36.2	7.0 (7)	1.7–28.7	25.0 (5)	3.0–206.6	1.1 (12)	0.2–4.2	1.6 (3)	0.9–3.0		
2 Difficulty sustaining attention	10.2 (6)	5.2–20.1	0		20.2 (4)	9.5–42.7	7.6 (6)	2.0–29.4	18.8 (6)	3.7–95.7	1.1 (11)	0.2–5.3	1.2 (7)	0.5–2.6		
3 Does not seem to listen	3.6 (16)	1.7–7.3	1		11.2 (13)	5.2–24.3	3.0 (18)	0.6–15.1	6.6 (14)	1.5–28.8	0.9 (14)	0.1–7.4	1.2 (9)	0.4–3.1		
4 Does not follow through	13.8 (4)	6.9–27.4	4.2	1.7–9.9	19.6 (5)	9.2–41.5	6.8 (8)	1.7–26.1	39.8 (2)	4.8–329.3	0.4 (19)	0.0–3.6	1.1 (11)	0.5–2.3		
5 Difficulty organizing tasks	3.9 (15)	1.9–8.1	0		13.8 (12)	6.3–30.2	5.6 (10)	1.3–23.7	3.6 (20)	0.7–18.8	2.1 (6)	0.4–10.3	0.7 (16)	0.2–2.2		
6 Reluctant to engage in “mental” tasks	9.1 (9)	5.1–16.0	2		13.9 (11)	6.6–29.0	3.3 (17)	0.8–12.8	13.1 (9)	2.5–66.1	0.3 (20)	0.0–2.8	1.1 (12)	0.5–2.9		
7 Loses objects	6.3 (13)	3.1–13.0	0		9.5 (18)	4.5–20.0	2.4 (20)	0.5–12.3	29.2 (4)	5.6–149.7	0.7 (17)	0.0–6.0	0.9 (14)	0.4–2.4		
8 Easily distracted	8.8 (10)	5.0–15.5	1		9.5 (18)	4.5–20.0	5.1 (11)	1.3–19.7	30.0 (3)	3.6–248.1	0.7 (16)	0.1–3.6	1.0 (13)	0.5–2.1		
9 Forgetful	11.2 (5)	5.7–21.9	2		18.4 (8)	8.7–38.7	4.5 (12)	1.1–17.3	42.2 (1)	5.1–349.6	0.4 (18)	0.0–3.8	1.1 (10)	0.5–2.4		
10 Fidgets	3.5 (18)	1.9–6.5	1		10.7 (14)	5.2–22.0	3.6 (15)	0.8–15.0	12.8 (10)	2.9–55.3	2.4 (4)	0.6–9.2	0.4 (21)	0.1–1.4		
11 Gets up	6.5 (12)	3.2–12.9	5	1.9–13.29	14.2 (9)	6.8–29.7	4.0 (14)	0.9–16.6	14.1 (8)	3.2–61.2	2.6 (2)	0.6–10.1	0.7 (18)	0.2–1.8		
12 Runs about	3.6 (16)	1.7–7.3	0		11.2 (13)	5.2–24.3	3.0 (18)	0.6–15.1	6.6 (14)	1.5–28.8	0.9 (14)	0.1–7.4	1.2 (8)	0.4–3.1		
13 Excessively loud	8.2 (11)	3.5–19.5	0		24.0 (1)	10.7–53.9	5.8 (9)	1.3–24.5	12.1 (11)	2.9–50.9	2.2 (5)	0.4–10.6	1.3 (5)	0.5–3.3		
14 On the go	3.9 (15)	1.9–8.1	0		13.8 (12)	6.3–30.2	5.6 (10)	1.3–23.7	3.6 (20)	0.7–18.8	2.1 (6)	0.4–10.3	0.7 (16)	0.2–2.2		
15 Talks excessively	2.6 (20)	1.5–4.4	1		6.0 (19)	3.0–12	4.2 (13)	1.1–16.4	5.3 (17)	1.3–22.0	2.6 (3)	0.7–9.0	0.5 (20)	0.2–1.3		
16 Blurts out answers	3.2 (19)	1.6–6.4	0		9.7 (17)	4.5–20.8	8.2 (3)	2.1–32.0	6.0 (16)	1.3–26.1	0.8 (15)	0.1–6.7	0.6 (19)	0.2–1.9		
17 Difficulty waiting his turn	4.5 (14)	2.3–8.9	3		14.0 (10)	6.6–29.4	18.8 (1)	4.5–78.4	5.2 (18)	1.2–22.6	1.6 (10)	0.3–7.9	0.7 (17)	0.2–2.0		
18 Interrupts or intrudes	3.5 (17)	1.8–6.9	0.2	0.07–0.6	10.3 (15)	4.9–21.8	7.7 (5)	2.0–30.1	9.7 (12)	2.3–40.5	1.8 (9)	0.3–8.6	1.2 (6)	0.5–3.0		
19 Acts without thinking	20.9 (2)	7.2–60.0	0		22.9 (2)	10.5–49.8	8.0 (4)	2.0–31.0	17.2 (7)	3.9–75.0	1.8 (8)	0.3–8.8	1.6 (4)	0.7–3.6		
20 Impatient	19.4 (3)	6.7–55.9	12.4	3.7–41.6	18.7 (7)	8.6–40.6	8.5 (2)	2.1–33.1	6.2 (15)	1.4–27.0	3.4 (1)	0.8–13.1	2.0 (2)	0.9–4.5		
21 Uncomfortable doing things slowly	9.2 (8)	3.7–23.0	0		10.1 (16)	4.5–22.4	3.4 (16)	0.6–17.3	4.0 (19)	0.7–20.9	1.0 (13)	0.1–8.4	0.8 (15)	0.2–2.5		
22 Difficulty to resist temptations	35.3 (1)	4.6–267.4	0		22.5 (3)	8.2–61.9	2.8 (19)	0.3–24.2	8.1 (13)	1.5–43.6	2.0 (7)	0.2–16.9	2.559 (1)	0.8–7.4		

Regression values are shown as adjusted odds ratios with 95 % confidence intervals. APS regression is shown as the number of appearances among the 10 top-ranked five-item subsets
OR odds ratio, CI confidence interval

according to parents or teachers. The new four impulsivity items did not change the overall accuracy for identifying impaired individuals. For inattentive dimension in both DSM-IV and DSM-5 WG ADHD diagnosis, the best cutoff point for predicting impairment was two symptoms (DSM-5 WG parents: $AUC = 0.755$, teachers: $AUC = 0.775$) (findings on DSM-IV were not shown but available upon request). The best cutoff point for the hyperactivity/impulsivity dimension was two symptoms according to both the nine symptoms of DSM-IV criteria and the 13 symptoms of DSM-5 WG criteria (DSM-5 WG parents: $AUC = 0.728$, teachers: $AUC = 0.668$). Findings on DSM-IV were not shown but available upon request.

Discussion

This study was able to investigate the validity of four new impulsivity items for ADHD. First, we showed that the rate of disagreement between the DSM-IV and DSM-5-WG proposal is somewhat high given that, from the 51 subjects identified with ADHD by either approaches, only 31 would agree by both methods. Second, we found that factor structure of ADHD symptoms would remain unchanged with the addition of new items, but the new items might perform slightly better on capturing the severe end of ADHD latent trait. Third, we demonstrated that one of the four new impulsivity symptoms (impatient) was part of the list of best predictors of impairment according to both parents and teachers. Lastly, the four new impulsivity items did not change the overall accuracy for identifying impaired individuals in ROC analysis.

For both parents and teachers, the bifactor model with a general factor and three specific factors had the best model fit compared with the other models in both DSM-IV and DSM-5 solutions. Our factor analysis data showed that new four impulsivity symptoms were slightly better at informing about specific impulsivity factor than older impulsivity items, but not strong enough to constitute a specific factor. One of the four new impulsivity items “Difficulty to resist temptations” was the most important item to capture severe ADHD cases among all 22 DSM-5 WG items on ADHD. Recent papers assessing the factor structure of DSM-IV ADHD criteria in children also found that the bifactor solution with a stronger general factor and three specific factors was the best one to fit the data [27]. However, these papers did not assess the factor structure including more impulsivity items. The only previous paper addressing factor analysis of 22 DSM-5 WG ADHD symptoms in adults found that three-factor solution provided a significantly better fit for the data than two factor solution [9].

In univariate regression analysis, our results indicate that new 4 impulsivity items were the best predictors of

impairment among all 22 DSM-5 WG items on ADHD. In the three-step analysis, one of the four new impulsivity items “impatient” had a strong association with impairment according to both teachers and parents report. Previous literature clearly documents the importance of impulsivity as a core ADHD feature. In an adult ADHD study, ADHD persistent cases had higher emotional impulsiveness scores than both non-persistent type of ADHD and the community groups [8]. These higher scores were related to greater degrees of impairment in various major life activities [8]. Also, this study was in line with a prior work suggesting that EI symptoms were a single construct that is highly correlated with the two dimensions of ADHD [28] and impulsivity symptoms split off from hyperactivity symptoms [29], which was also showed in our analysis (impulsivity and hyperactivity were showed to be separate domains). The only previous paper that assessed specifically the role of the four new impulsivity items in predicting impairment found that no consistent pattern of association was detected with clinical impairment for the four new impulsivity symptoms as a group [9].

Moreover, our results confirm findings from a previous work that documented a low specificity of the four new impulsivity symptoms for the diagnosis of ADHD in children and adolescents. Only one of these items ‘Impatient’ was detected as more specific for ADHD compared to other psychiatric disorders [10]. In our analyses, there was no item that was specifically associated with ADHD according to both parents and teachers.

We detected that a lower symptom threshold than the one proposed in both DSM-IV and DSM-5 criteria had the best balance between sensitivity and specificity at predicting impairment for both inattention and hyperactivity/impulsivity dimensions using ROC analyses. Our findings concur with previous literature also suggesting that a lower threshold works better in predicting impairment in adults [9, 30, 31].

Our study should be understood in the context of some limitations. Although just one clinician applied the KSDAS-PL increasing the reliability of data, we cannot exclude an assessment bias, even considering the extensive training provided by the Turkish Association of Child and Adolescent Psychiatry. This condition may have determined a higher agreement between DSM-IV and DSM-5 results. Another limitation was the moderate sample size. Thus, our findings should be replicated in a large sample size. Also, our findings were obtained in a community sample and results should not be extrapolated to clinical samples where the level of ADHD severity is frequently higher. And, our results were derived from a sample of Turkish children. Thus, their generalization to other cultures should be done with caution. In addition, our analyses between agreement and disagreement groups might be

underpowered. Although we used the same wording as proposed by the DSM-5 ADHD committee for the four new impulsivity items, wording used on two of them ('Uncomfortable doing things slowly' and 'Difficulty to resist temptation') requests something that is not easily assessed by observers (e.g., informants can assess if a subject is doing something slowly, but not easily evaluate the level of discomfort). Finally, our impairment measure was not specific for ADHD. Thus, association between symptoms and impairment might be reflecting more general impairment than ADHD specific impairments.

Overall, our findings suggest that, although impulsivity might be an important core dimension of the disorder, the determination on how to best capture it as part of the general ADHD construct needs more investigation. The simple inclusion of the proposed four new impulsivity symptoms by the DSM-5 WG seems to add some value in terms of capturing specific impairment and perform somewhat better than current items with respect to the factor structure. Nevertheless, in the iterative model in which DSM-5 was constructed that requires sufficient evidence to change, this little incremental value seems insufficient to overcome challenges of changing diagnostic criteria, such as the need to reassess prevalence and correlates of the new criteria and to modify ADHD scales, challenging comparability with research over the last 20 years [9].

Compliance with ethical standards

Conflict of interest Luis A. Rohde has received honoraria, has been on the speakers' bureau/advisory board and/or has acted as a consultant for Eli-Lilly, Janssen-Cilag, Novartis and Shire in the last 3 years. He receives authorship royalties from Oxford Press and ArtMed. He also received travel awards for taking part of 2014 APA and 2015 WFADHD meetings from Shire. The ADHD and Juvenile Bipolar Disorder Outpatient Programs chaired by him received unrestricted educational and research support from the following pharmaceutical companies in the last 3 years: Eli-Lilly, Janssen-Cilag, Novartis, and Shire. Eyup Sabri Ercan is in charge of the advisory board of Lilly and Janssen-Cilag. The other authors have no biomedical financial interests or potential conflicts of interest to report.

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