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Internal and external validity of Attention-Deficit Hyperactivity Disorder in a population-based sample of adults

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ABSTRACT

Background. Follow-up studies of childhood ADHD have shown persistence of the disorder into adulthood, but no epidemiological data are yet available.

Method. ADHD DSM-IV symptoms were obtained by self-report in an adult population-based sample of 1813 adults (aged 18–75 years), that was drawn from an automated general practitioner system used in Nijmegen, The Netherlands. The structure of ADHD symptoms was analysed by means of confirmatory factor analyses. Other data used in this report are the General Health Questionnaire (GHQ-28), information about the presence of three core symptoms of ADHD in childhood, and about current psychosocial impairment.

Results. The three-factor model that allowed for cross-loadings provided the best fit in the entire sample. This result was replicated across gender and age subsamples. Inattentive and hyperactivity symptom scores were significantly associated with measures of impairment, even after controlling for the GHQ-28. Subjects with four or more inattentive or hyperactive–impulsive symptoms were significantly more impaired than subjects with two, one and no symptoms. The prevalence of ADHD in adults was 1·0% (95% CI 0·6–1·6) and 2·5% (1·9–3·4) using a cutoff of six and four current symptoms respectively, and requiring the presence of all three core symptoms in childhood.

Conclusions. These results support the internal and external validity of ADHD in adults between 18 and 75 years. ADHD is not merely a child psychiatric disorder that persists into young adulthood, but an important and unique manifestation of psychopathology across the lifespan.

INTRODUCTION

Attention-Deficit Hyperactivity Disorder (ADHD) is increasingly recognized as a diagnostic entity in adult psychiatric services. Follow-up studies of clinic-referred samples of children with ADHD indicate that the disorder persists into adulthood in 10–60% of the cases (Weiss *et al.* 1985; Mannuzza *et al.* 1993). The considerable variation in level of persistence across studies probably reflects different definitions of remission from ADHD over time and symptom type (Biederman *et al.* 2000). There is further converging evidence that ADHD in adults can be reliably diagnosed (Murphy, 1996) and shows similar patterns as ADHD in children of psychiatric co-morbidity (Biederman

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et al. 1993), learning problems (Biederman *et al*. 1993; Barkley *et al*. 1996), family-genetic correlates (Faraone *et al*. 2000), brain correlates (Zametkin *et al*. 1990; Dougherty *et al*. 1999; Castellanos *et al*. 2001) and treatment response (Spencer *et al*. 1995; Wilens *et al*. 1996).

In spite of an accumulating database on ADHD in adults, a number of pivotal issues have yet to be addressed. The first one is whether the symptoms of ADHD in adults fit into the same two-factor [inattention (IA) and hyperactivity–impulsivity (HI)] or three-factor models [inattention (IA), hyperactivity (H), and impulsivity (I)] that have been found in children and are reflected in the current conceptualization of ADHD in DSM-IV. The 18 symptoms of DSM-IV ADHD are spread over three separate dimensions: IA (nine symptoms), H (six symptoms) and I (three symptoms). Furthermore, DSM-IV describes three types of ADHD: combined type (at least six IA and at least six H and I or HI symptoms), inattentive type (at least six IA symptoms) and hyperactive–impulsive type (at least six HI symptoms). This scheme of three subtypes was chosen largely on the basis of a number of exploratory factor analytical studies using ADHD symptoms contained in DSM-III and DSM-III-R (Lahey *et al*. 1988; Pelham *et al*. 1992; Baumgaertel *et al*. 1995). These studies provided support for two independent factors: IA and HI.

A second issue is that data on prevalence and impairment of functioning of adult ADHD obtained directly from community studies are absent. Among a convenience sample of 720 adults applying for or renewing their driver's licence, the occurrence of self-reported DSM-IV ADHD symptoms amounted to an overall prevalence of adult ADHD of 4·7% (1·3% inattentive type, 2·5% hyperactive–impulsive type, and 0·9% combined type) (Murphy & Barkley, 1996). The cutoff of six or more out of nine criteria for ADHD in DSM-IV was derived by calibrating measures of impairment of functioning *versus* symptom counts (Lahey *et al*. 1994).

This study utilized self-report data on current ADHD DSM-IV symptoms in a Dutch population-based sample of adults between 18 and 75 years of age, to address the issues detailed above.

METHOD

Sample

The data were collected in the context of the Nijmegen Health Area Study-2 (NHA-2) that was designed to assess the prevalence and distribution of psychiatric morbidity in the region of Nijmegen, The Netherlands. The NHA-2 is based on a probability sample of subjects registered in the practice of a general practitioner (GP). Since nearly every inhabitant of The Netherlands is registered with a GP practice, the degree of this registration is equivalent to that of the register offices. A random sample of 5% ($n=4517$) of the total population of 80 315 subjects between 18 and 75 years old was asked to participate. From those, 45·4% ($n=2049$) gave written informed consent. In the end 1813 subjects were available for data collection between September 1997 and March 1998; this constitutes the study sample. The composition of the sample by gender and age was as follows: men (44·7%), women (55·3%); age: 18–29 years (14·9%), 30–44 years (37·5%), 45–59 years (30·0%), 60–75 years (17·7%). Men and younger subjects were under-represented in the study sample, compared to the general population of The Netherlands [Central Bureau of Statistics (CBS), 1997]. Accordingly, the prevalence data were weighted to approximate the distribution of these demographic variables in the general population. A further comparison of participants and non-participants showed no differences in prescription of psychotropic medication by the GPs. This indicates that selection bias with respect to psychiatric disorders was unlikely.

Procedure and measures

Experienced interviewers of the Institute of Applied Sociology in Nijmegen interviewed the study sample. The interview covered sociodemographic variables, the General Health Questionnaire (GHQ; Goldberg & Williams, 1988), variables on psychosocial impairment and a Dutch version of the ADHD DSM-IV rating scale (DuPaul *et al*. 1998). Almost 1800 questionnaires were completed and returned (response rate 99%). Demographic variables registered were: age, gender and income.

The GHQ-28 was used as a measure of general liability to psychopathology. Psychosocial

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impairment was measured by four items. The items about the current presence of self-perceived psychological disorder and the current use of medication for psychological disorder were binary coded (yes/no). The third item asked about whether mental health problems did interfere with social contacts over the past 4 weeks, and was coded on a five-point scale ('not at all' to 'very much'). The fourth item asked about whether mental health problems did interfere with social activities over the past 4 weeks, and was coded on a six-point scale ('not at all' to 'always'). We computed an aggregated measure of psychosocial impairment by averaging the scores of the four single items after these had been rescaled to unity. The range of this aggregated measure is from 0 to 1, with higher scores reflecting greater overall impairment. Cronbach's alpha was 0·72

A Dutch version of the ADHD DSM-IV rating scale was constructed using the 18 DSM-IV items for ADHD (DuPaul *et al.* 1998). Symptoms were reported over the last 6 months. To facilitate a reliable self-report, five complex items were reformulated in two single statements. IA item 1 was reformulated into 'fail to give close attention to details in work' and 'make careless mistakes in work'; IA item 4 into 'difficulty following through on instructions' and 'fail to finish activities or work'; HI item 1 into 'fidget with hands or feet' and 'squirm in seat'; HI item 3 into 'feel restless' and 'get bored quickly'; and HI item 4 into 'difficulty to relax in leisure time' and 'holidays or leisure time in busy and noisy environment'. Each item was to be rated on a four-point scale (0='rarely or never', 1='sometimes', 2='often', 3='very often') based on current behaviour within the past 6 months. In rendering each item on the scale, the word 'often' was eliminated from the wording of each item in the original DSM-IV list. IA and HI items alternated in their sequence listed on the scale. We added three items based on the retrospective recall of the presence of inattentive, hyperactive and impulsive behaviour in childhood, around 7–8 years of age. The childhood items were also rated on a four-point scale (0='rarely or never', 1='sometimes', 2='often', 3='very often'). Thus, the self-report questionnaire consisted of 26 items in total, with 23 items on current ADHD symptoms and three childhood items. A symptom was considered as present if the answer given to the item was 'often' or 'very often' (score of 2 or 3). In analyses on prevalence, the 23 current item scores were recalculated to the original 18 DSM-IV items. For childhood symptoms a score 'often' or 'very often' on all three items was considered clinically relevant and taken as an index of the presence of ADHD in childhood. This turned out to be the case for 2·8% of the population.

Statistical analysis

To avoid a loss of information due to the required listwise deletion in some of our analyses, missing responses (in 42 subjects up to four missing items per subject) were replaced by imputed values using the EM algorithm as implemented in SPSS 9.0 (SPSS Inc., Chicago, IL, USA) (Dempster *et al.* 1977). A comparison between the correlation matrix computed using the imputed values *versus* the correlation matrix computed using pairwise deletion showed that this hardly affected the input matrix (mean difference = −0·003, S.D. of mean difference = 0·007).

The factor structure of the 23 current ADHD symptoms was examined by confirmatory factor analyses using the computer program Mplus (Múthen & Múthen, 1998). Five competing models were evaluated. The first model assumed that all items loaded on a single common factor. The second model made a distinction between IA and HI subtypes. To account for the fact that subjects may suffer from both subtypes (i.e. the combined type), the IA and HI factors were allowed to correlate. The second model assumed a perfect simple structure, in which the items only loaded on the factor that they were supposed to measure. A third model included a common IA and HI factor similar to the second model, but allowed for cross-loadings. The fourth model included the IA factor and in addition specified separate factors for the H and I symptoms as distinguished in DSM-IV and assumed a perfect simple structure. To deal with co-morbidity, the correlations among the three factors were estimated. The fifth model included the three common factors IA, H and I like the fourth model, but allowed for cross-loadings. It is not possible to estimate all

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Table 1. *Standardized factor loading in best-fitting simple structure model*

	Item	DSM-IV domain	IA factor	H factor	I factor
14[a]	Difficulty organizing tasks and activities	IA	0·70	—[b]	−0·17
22	Forgetful in daily activities	IA	0·66	—	—
18	Lose things necessary for tasks or activities	IA	0·60	—	—
5	Difficulty sustaining attention in tasks	IA	0·59	0·24	−0·17
16	Avoid or reluctant to engage in tasks requiring sustained mental effort	IA	0·59	0·10	−0·12
10	Difficulty following through on instructions	IA	0·57	—	—
11	Fail to finish activities or work	IA	0·57	—	−0·10
3	Make careless mistakes in work	IA	0·50	—	—
20	Easily distracted	IA	0·43	0·30	—
7	Do not listen to what is being said	IA	0·37	—	0·24
1	Fail to give close attention to details in work	IA	0·34	—	—
8	Feel restless	H	0·25	0·63	−0·17
12	Difficulty to relax in leisure time	H	0·26	0·56	−0·24
4	Squirm in seat	H	—	0·54	—
15	'On the go' or act as if 'driven by a motor'	H	—	0·52	—
9	Get bored quickly	H	0·21	0·51	−0·21
2	Fidget with hands or feet	H	—	0·43	—
17	Talk excessively	H	−0·13	0·35	0·33
13	Holidays or leisure time in busy and noisy environment	H	—	0·30	—
6	Leave seat in situations where it is inappropriate	H	0·18	0·27	—
23	Interrupt or intrude on others	I	—	—	0·79
19	Blurt out answers before questions have been completed	I	—	0·15	0·64
21	Difficulty awaiting turn	I	0·13	0·22	0·34

[a] Listing of item in the Dutch ADHD DSM-IV rating scale.
[b] —, Indicates that factor loading is fixed to zero; IA, inattention; H, hyperactivity; I, impulsivity.

(cross-)loadings and identifying constraints need to be imposed via a rotation criterion (Jöreskog, 1978).

To evaluate the factor models, multiple-fit criteria were used. First, the Satorra–Bentler rescaled χ^2 was applied (Satorra & Bentler, 1988). Secondly, Akaike's Information Criterion (AIC) was used (Akaike, 1987; Williams & Holahan, 1994). Finally, we used the Tucker–Lewis Index (TLI) and the Comparative Fit Index (CFI) that reflect the improvement in fit compared to a baseline model (Marsh *et al.* 1988; Múthen & Múthen, 1998; Bentler, 1990). The TLI and CFI usually range from 0 to 1 and, similar to the AIC, apply a penalty function for estimating more parameters. Larger values imply a better fit so that the model with the TLI and CFI closest to 1 was selected.

The relationships between the ADHD DSM-IV symptom domains of IA and HI and measures of psychosocial impairment were examined by logistic regression, multiple linear regression, analysis of covariance (including GHQ-28 as covariate) and Receiver-operating characteristic (ROC) analyses, using SPSS 9.0.

RESULTS

Confirmatory factor models

The results of the confirmatory factor analyses show that the three-factor model that allowed for cross-loadings was selected as the best-fitting model by all fit indices. Thus, this model had the smallest AIC and the largest TLI and CFI ($\chi^2 = 723{\cdot}73$, df = 206, AIC = 311·73, TLI = 0·926, CFI = 0·939). A comparison with the three-factor cross-loading model showed that on the basis of the degrees of freedom, the AIC and the TLI, this latter model should be preferred in terms of parsimony and fit.

The standardized factor loadings in the best-fitting simple structure are shown in Table 1. To compose this table, the items were allocated to the factor on which they had the highest loading. Next, the loadings of each factor were sorted in descending order. Table 1 shows that all items loaded highest on the factor they were supposed to measure according to the description in DSM-IV. Furthermore, when a loading of 0·3 was used as a cut-off above which an item was viewed as a reliable indicator of that factor, all these factor loadings were larger

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than 0·3, except for H item 6 'leave seat'. Finally, only two items (IA item 'easily distracted' and H item 'talks excessively') had cross-loadings of $\geqslant 0{\cdot}3$. Thus, the vast majority of items possessed the desirable property that they were indicators of the intended factor only.

In the best-fitting simple structure the estimated correlations between IA and H, IA and I, and H and I were 0·57, 0·50, and 0·47 respectively. This indicated that on the one hand the three factors shared a proportion of their variance, and on the other tapped different aspects of ADHD. Cronbach's alphas for IA, H, and I were 0·83, 0·75, and 0·72 respectively.

Replications using tetrachoric correlations, across gender and age subgroups

To study the robustness of the results the analyses were repeated using polychoric correlations in combination with an asymptotically distribution free estimation method (ADF; Browne, 1984). The three-factor cross-loading model was again selected by all fit indices as the best-fitting model. This replicated the results with the maximum-likelihood approach and provided support for the robustness of the findings.

The analyses were also performed for males and females and for two age groups of the same size separately. The three-factor cross-loading model was selected again as the best-fitting model in all groups and by all fit indices. To examine whether in addition to the general model the parameter estimates were also identical, we fitted the best-fitting simple structure model with and without equality constraints across groups. For the comparison between males and females constraining the parameters to be equal ($\chi^2 = 1051{\cdot}151$, df = 482, AIC = 87·15, TLI = 0·931, CFI = 0·935) did not yield a much poorer fit than estimating different parameters in each group ($\chi^2 = 959{\cdot}24$, df = 412, AIC = 135·24, TLI = 0·923, CFI = 0·937). This suggested that the parameter estimates were similar in males and females. For the comparison between the young and old cohort the fit indices were $\chi^2 = 1086{\cdot}13$, df = 482, AIC = 122·13, TLI = 0·925, CFI = 0·928 for the model assuming equal parameters, and $\chi^2 = 959{\cdot}24$, df = 412, AIC = 123·98, TLI = 0·922, CFI = 0·936 for the model without equality constraints. These fit indices were not completely consistent, with the CFI suggesting age differences whereas the TLI and AIC did not.

Table 2. *Correlations between ADHD symptom factors in adults and demographic characteristics, GHQ, and psychosocial impairment*

	IA	H	I
Demographic characteristics			
Gender (male = 0, female = 1)	−0·01	0·09*	0·04
Age	0·04	−0·16*	−0·01
Income	−0·08*	−0·07*	0·00
General Health Questionnaire			
Total score GHQ-28	0·45*	0·48*	0·24*
Somatic symptoms	0·39*	0·43*	0·21*
Anxiety and sleep problems	0·39*	0·46*	0·24*
Social dysfunctioning	0·35*	0·29*	0·14*
Depression	0·38*	0·40*	0·21*
Childhood ADHD symptoms (retrospective)			
Inattention	0·25*	0·36*	0·25*
Hyperactive	0·39*	0·38*	0·24*
Impulsive	0·29*	0·33*	0·29*
Impairment			
Psychological disorder	0·29*	0·32*	0·15*
Medication for psychological disorder	0·22*	0·27*	0·12*
Social contacts	0·31*	0·34*	0·17*
Social activities	0·31*	0·30*	0·14*

IA, inattention; H, hyperactivity; I, impulsivity.
* $p < 0{\cdot}05$.

External validity

The external validity of the ADHD symptom factors was studied via correlations with demographic variables, the GHQ, retrospective self-ratings of ADHD symptoms in childhood, and self-rated psychosocial impairment (see Table 2). The number of H symptoms was somewhat higher in women and in subjects of young age, and both H and IA symptoms were more present in subjects with low income. The effect of gender on the number of H symptoms remained after controlling for GHQ-28 since women had also higher scores on the GHQ (partial correlation 0·08, $p < 0{\cdot}001$). All correlations involving the GHQ scales were significant. Correlations were larger for IA and H symptoms than for I symptoms. The largest correlations were found for the GHQ-28 total score. The correlations with the IA, H, or I childhood symptoms suggested some extent of specificity. That is, H showed the highest correlation with the H childhood symptom, and I with the I childhood symptom.

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Table 3. *Logistic regression of self-assessed presence of psychological disorder on ADHD symptom counts with and without the GHQ-28*

	B	S.E. *b*	Wald statistic	df	*p*
Without GHQ-28					
H	0·196	0·030	41·795	1	0·000
IA	0·124	0·025	25·021	1	0·000
I	−0·081	0·069	1·408	1	0·235
With GHQ-28					
H	0·123	0·034	13·194	1	0·000
IA	0·066	0·027	6·229	1	0·013
I	−0·017	0·073	0·053	1	0·819
GHQ-28	1·868	0·228	66·971	1	0·000

IA, inattention; H, hyperactivity; I, impulsivity.

The final set of correlations indicated that ADHD symptoms are associated with impaired psychosocial functioning. Thus, subjects with many symptoms were more likely to report having a psychological disorder, receive medication for a psychological disorder, and indicate that their disorder affects their social contacts and activities negatively.

To examine whether IA, H, and I made unique contributions to the prediction of psychosocial impairment scores or reflected a general ADHD liability, logistic regression and multiple linear regression models were built. Results were remarkably consistent showing significant and unique contributions of the IA and H factor to all four impairment measures (see Table 3 for the prediction of self-assessed psychological disorder). This indicated that distinction between IA and H symptoms was clinically meaningful. The I symptoms showed a small negative effect that was significant in approximately half of the regression equations.

Next, we explored whether the ADHD symptom factors are merely an indicator of a general liability for psychopathology or reflect a specific liability. To this end, the GHQ-28 as a measure of the general liability was included with the ADHD symptom factors in a logistic regression analysis with the self-assessed presence of a psychological disorder as dependent variable (Table 3). The results showed that the effects of IA and H remain significant, even after the inclusion of the GHQ-28. The ADHD symptom factors appear to capture a unique aspect of psychopathology that is not measured by the GHQ.

Impairment and prevalence rates

To examine the relationships between ADHD symptoms and impairment of functioning and to determine the prevalence of ADHD in the present sample, the original 18 DSM-IV items were retrieved. A problem in the study of ADHD in adults is the choice of the diagnostic threshold. One option is to use the threshold of six out of nine symptoms for each domain of IA and HI, as specified for children in DSM-IV. However, children are normally more active and have more difficulty in concentrating than adults, leading to a higher base-rate of symptom levels in children than in adults. One may, therefore, argue that the threshold should be set lower in adults, who might experience impairment at fewer symptoms. To estimate the diagnostic threshold in adults, the number of IA and HI symptoms was plotted *versus* the aggregated measure of impairment, while using the GHQ-28 as a covariate (Fig. 1). Analyses of covariance (ANCOVAs) (between-subjects factor 'number of symptoms' in seven levels: 6 or more symptoms, 5, 4, 3, 2, 1, and 0 symptoms; and GHQ-28 as covariate) indicated that subjects with four or more IA symptoms had impairment scores that were significantly increased compared to lower levels of 2, 1 or 0 IA symptoms [overall model $F(7, 1709) = 144{\cdot}631$, $p < 0{\cdot}000$, 'number of symptoms' $F(6, 1709) = 7{\cdot}371$, $p < 0{\cdot}000$]. In a similar analysis of covariance, subjects with four or more HI symptoms were significantly more impaired than subjects with lower levels of 3, 2, 1 and 0 HI symptoms [overall model $F(7, 1709) = 153{\cdot}963$, $p < 0{\cdot}000$, 'number of symptoms' $F(6, 1709) = 10{\cdot}973$, $p < 0{\cdot}000$]. Subsequent ANCOVAs that included gender and age in addition to GHQ-28 as covariates, and ANCOVAs for men and women and for young and old subjects separately replicated the finding of a cutoff of four symptoms. Once IA and HI symptom counts had been included, regression models indicated that impairment was just linearly related to counting IA symptoms, with no evidence of any additional impairment at the cutoff of four symptoms (Fig. 1). For HI symptoms, however, a cutoff of four symptoms was associated with additional impairment ($p < 0{\cdot}05$).

We further explored the relationships between ADHD symptoms and impairment in

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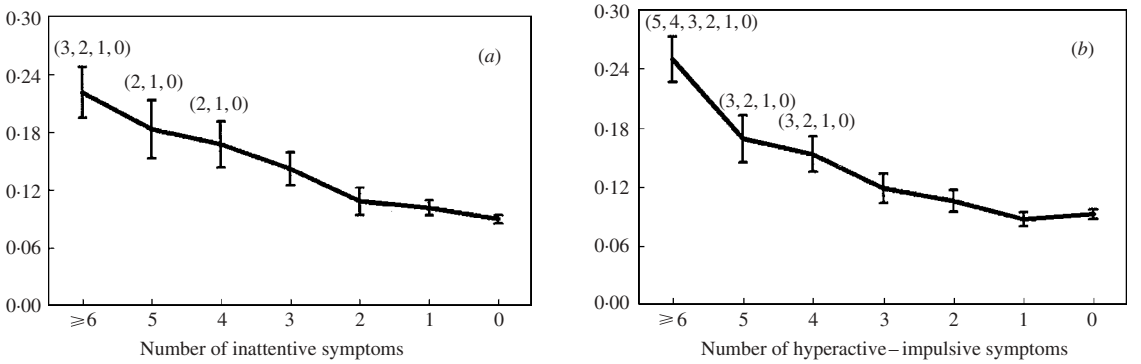


FIG. 1. Composite measure of impairment by (*a*) number of inattentive symptoms and (*b*) hyperactive–impulsive symptoms, with GHQ-28 as covariate. Figures within parentheses indicate that groups with four or more inattentive or hyperactive–impulsive symptoms were significantly more impaired than, for example subjects with 2, 1 and 0 symptoms ($p < 0{\cdot}05$, least-square differences).

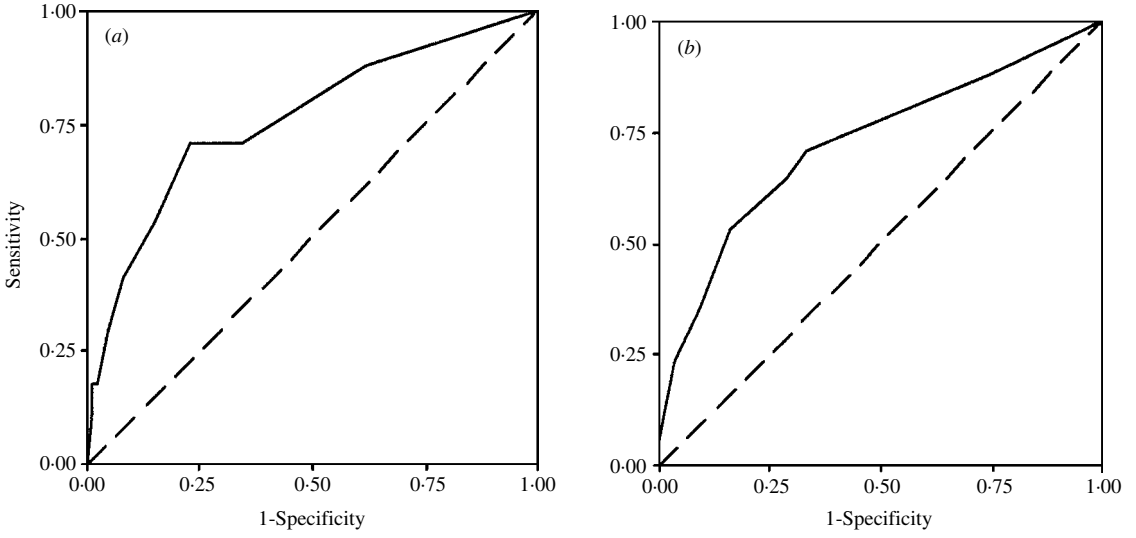


FIG. 2. ROC curves of (*a*) number of inattentive symptoms and (*b*) number of hyperactive–impulsive symptoms *versus* 95% percentile cutoff of impairment.

ROC analyses, using the 95th percentile of impairment as cut-off point (Fig. 2). The area under the curve (AUC) for the number of inattentive, and hyperactive–impulsive symptoms respectively was 0·760 ($p < 0{\cdot}01$; S.E. = 0·069, 95% CI 0·624–0·895) and 0·724 ($p < 0{\cdot}01$; S.E. = 0·074, 95% CI 0·579–0·870). The optimal trade-off between sensitivity and specificity for both inattentive and hyperactive–impulsive symptoms was obtained at the threshold of three symptoms (inattentive symptoms: sensitivity = 0·71, specificity = 0·77; hyperactive–impulsive symptoms: sensitivity = 0·71, specificity = 0·67).

On the basis of these analyses, it seems justified to conclude that on average the presence of four or more ADHD symptoms of either IA or HI is associated with significantly increased self-perceived psychosocial impairment, even after controlling for the level of general psychopathology as reflected in the GHQ-28.

By the application of a cutoff of six current ADHD symptoms and the presence of all three symptoms in childhood, a weighted prevalence of overall ADHD of 1·0% (95% CI 0·6–1·6) was obtained. The prevalences of the subtypes were 0·2% for the inattentive, 0·5% for the

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hyperactive–impulsive and 0·3% for the combined subtype. There was no significant gender effect using this cutoff. A cutoff of four current ADHD symptoms and the presence of all three symptoms in childhood implied a weighted prevalence of ADHD of 2·5% (95% CI 1·9–3·4), including 0·3% for the inattentive, 1·2% for the hyperactive–impulsive and 1·0% for the combined subtype. Using the cutoff of four symptoms, women had a higher prevalence of ADHD than men [odds ratio (OR) 2·6, 95% CI 1·4–4·7, $p<0·05$]. There were no significant age effects on prevalence.

DISCUSSION

This article examined the factor structure of ADHD symptoms in adults 18–75 years of age in a community sample in The Netherlands. Confirmatory factor analyses provided strong support that the three-factor model with factors IA, H, and I as specified in the DSM-IV and as devised for children can be generalized to adults. The three-factor structure that allowed for cross-loadings proved to be rather robust and independent of gender and could be replicated in analyses in young as well as old subjects. The internal consistency of the symptom factors was somewhat lower than that reported for parent and teacher ratings of similar factors in children (Gomez *et al*. 1999). Possible explanations are: (1) the inter-item correlations in adults are less inflated by gender and age effects; (2) symptom levels are lower in adults (Biederman *et al*. 2000) and due to lower symptom levels, the inter-item correlations become smaller (Van den Oord & Van der Ark, 1997); and (3) adult self-ratings are less affected by rater bias.

Although the confirmatory factor analyses favoured the three-factor over the two-factor solution, this is not equivalent to say that the two-factor model is invalid. The two-factor model in its turn had a significantly better fit than the one-factor model, and seems to be an acceptable model for the organization of the diagnostic symptoms of ADHD in adults. This implies that the division of the 18 ADHD symptoms into IA and HI domains for diagnosis as described in DSM-IV is reasonably appropriate in adults. The greater difference between the two-factor and three-factor models in adults than in children (Gomez *et al*. 1999) seems to be related to the different role of I symptoms in adults compared to that in children. In order to found future editions of the DSM classification of ADHD, the three-factor model should be further investigated in older age groups.

The external validity of the ADHD symptom factors in adults was apparent from meaningful and substantial correlations with the GHQ-28 and its subscales and with measures of self-rated psychosocial impairment. The IA and H symptom factors contributed significantly and independently to the prediction of the self-assessed presence of a psychological disorder after adjusting for the influence of general psychopathology, as indexed by the GHQ-28. The correlations of the childhood symptoms with the adult IA, H and I symptom factors suggest some stability of the syndrome over time, as has been shown in follow-up studies of children with ADHD derived from both clinical (Barkley *et al*. 1990) and community samples (Taylor *et al*. 1996).

A cutoff of four or more symptoms of IA or of HI was associated with a significant increase of overall psychosocial impairment, even after controlling for the influence of general psychopathology. This is lower than the cutoff of six symptoms, as derived for children in the DSM-IV Field Trial (Lahey *et al*. 1994). A lower threshold in adults than in children is in accordance with follow-up studies of children with ADHD (Biederman *et al*. 2000). These indicate that adults have on average less symptoms of ADHD than children and adolescents, but also that lower symptom levels in adults do not imply better functioning. A cutoff of six symptoms for adults may be overly restrictive and may possibly lead to under-diagnosis of ADHD in adults (Murphy & Barkley, 1996).

Most studies in children report substantially higher scores on ADHD symptom scales for boys (Buitelaar, 2002). By contrast, in this adult study gender effects were absent for IA and I symptoms and women even had slightly higher scores for H symptoms. The diagnostic threshold of four symptoms also identified a slightly higher prevalence in women. Another recent epidemiological study did report a higher prevalence of adult ADHD in males than in females (Kessler, 2004), whereas studies of the prevalence of ADHD symptoms in adult licensed

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drivers (Murphy & Barkley, 1996) and among a clinical sample of adult patients with ADHD (Kooij *et al*. 2001) did not find gender effects. In any case, higher scores for women on some aspects of ADHD are difficult to explain. We could rule out a confound by higher GHQ scores in women in our analysis of partial correlations. An explanation may be that ADHD symptoms in girls are relatively under-reported by significant others (i.e. parents and teachers), and that adult women themselves are rather sensitive to the presence of interfering ADHD symptoms. The issue of gender differences in HI is not new in fact. On the I_7 impulsiveness questionnaire some studies reported slightly higher scores on impulsiveness for women (Eysenck *et al*. 1985), whereas other studies found equal scores for men and women (Luengo *et al*. 1991; Caci *et al*. 2003). The conclusion is that more research into the role of gender in adult ADHD is needed.

Similar conclusions apply to the role of age. H symptoms showed a small but significant decline over age between 18 and 75 years. This suggests that the decline of H that starts before age 18 years (Biederman *et al*. 2000) continues thereafter. No age influences were found for IA and I symptoms, a finding discrepant from that in the adult licensed drivers study (Murphy & Barkley, 1996). In the National Cormorbidity Survey Replication in a population with an age span of 18–44 years no significant age effects were found (Kessler, 2004).

In spite of the developmental decline of H, the HI subtype was the most prevalent one in this sample, irrespective of the threshold used. This is in accordance with previous results in adults (Murphy & Barkley, 1996) but in contrast to findings from epidemiological studies in children and adolescents that report the inattentive type as the most prevalent one (Buitelaar, 2002).

Explanations may be that hyperactive and impulsive behaviour is relatively overrated in adults due to the use of symptom definitions designed for children, or that the self-report of adults differs qualitatively from the ratings of parents and teachers on symptoms in children, leading to a difference in distribution of symptom type. The validity of current hyperactive and impulsive symptom definitions for ADHD should, therefore, be assessed in adults.

Strengths and limitations

The present results should be interpreted in the context of the strengths and limitations of the study. Strengths included the population-based approach, the broad age range, and the fact that data were collected before the media hype about ADHD in adults started in The Netherlands and, therefore, biases were minimal. Limitations were that data on symptoms and impairment were obtained by self-report and information about ADHD in childhood was based on three core items. All findings here must be interpreted with the understanding that DSM-IV diagnostic requirements like age of onset of symptoms, pervasiveness across situations, and continuity of symptoms over time, have not been used in this analysis. The impairment assessed finally was not tailored to ADHD, i.e. did not reflect academic under-achievement or occupational problems. However, it may be reassuring to note that self-report of ADHD symptoms in adolescents tended to under- rather than over-report symptom levels (Danckaerts *et al*. 1999). Self-report was further found to be reliable compared to that of parents and partners and reveal meaningful and predicted associations with measures of impairment and outcome (Danckaerts *et al*. 1999; Murphy & Schachar, 2000; Smith *et al*. 2000; Mannuzza *et al*. 2002). However, future population-based surveys on ADHD in adults using structured interviews and incorporating specific impairment measures would be very valuable and should further clarify the role of gender and age. These studies may also address the issue of possible confound of ADHD ratings by mild symptoms of anxiety and depression by including more specific trait-like measures of these symptoms.

Clinical implications

There are several implications of the present findings that ADHD in adults between 18–75 years of age shows a similar make-up as ADHD in children and is correlated with impairment. This will broaden the focus and necessitate a reconceptualization of ADHD. It is not merely a child psychiatric disorder that persists into young adulthood, but an important and relatively unique manifestation of psychopathology across the whole lifespan. ADHD merits clinical

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and research attention in early as well as in late adulthood and to an equal degree in men and women. The threshold of six out of nine symptoms may be too restrictive to be applied to adults and merits further epidemiological research including clinical diagnosis. The particularly very identical structure of the inattentive symptom dimension in childhood, adolescence and adulthood will facilitate the study of the biological and genetic correlates of this dimension across the lifespan in the future.

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DECLARATION OF INTEREST

Dr Kooij and Dr Buitelaar are both consultants to and at the speakers bureau for Janssen-Cilag and Eli Lilly and Company. Dr Buitelaar has also served as consultant to Abbott. Dr E. J. van den Oord is a consultant to GlaxoSmithKline.

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