Predictability and construct validity of oppositional defiant disorder in children and adolescents with ADHD combined type

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Abstract

Background: Three recently identified dimensions of ODD (ODD-irritable, ODD-headstrong and ODD-hurtful) predict different future emotional and behavioral disorders. The present study aimed to test (1.) the diagnostic accuracy of two common parent rating scales in predicting ODD, (2.) the construct validity of the three dimensions of ODD and (3.) the prediction of these ODD-dimensions by two parent rating scales in a large referred sample of children and adolescents with ADHD combined type.

Methods: Receiver-operating characteristic analysis (ROC) was used in order to test the diagnostic accuracy of the Conners' parent rating scale revised (CPRS-R) and the parent version of the strength and difficulties questionnaire (PSDQ) in the prediction of ODD in a transnational sample of 1093 subjects aged 5-17 years from the International Multicentre ADHD Genetics (IMAGE) Study. In addition, confirmatory factor analysis of interview based ODD criteria aimed at the identification of three *a priori* defined dimensions, i.e., ODD-irritable, ODD-headstrong and ODD-hurtful. Finally, the prediction of these ODD-dimensions by the parent rating scales was assessed by backward linear regression analyses.

Results: ROC analyses showed adequate diagnostic accuracy of the CPRS-R and the PSDQ in predicting ODD in this ADHD sample. The three factor structure of ODD was partly confirmed and the CPRS-R emotional lability scale significantly predicted the ODD irritable dimension.

Conclusion: The PSDQ and the CPRS-R are both suitable screening instruments in the identification of ODD. The emotional lability scale of the CPRS-R is a predictor of irritability and severe mood dysregulation in youth referred for ADHD.

Keywords: Oppositional-Defiant Disorder; Attention-Deficit-Hyperactivity Disorder; Conners' Parent Rating Scale Revised; Strength and Difficulties Questionnaire; Irritability; Emotional lability.

Introduction

High rates of co-morbid oppositional defiant disorder (ODD) and conduct disorder (CD) have been found in subjects with ADHD (e.g. Angold *et al.*, 1999) and milder forms of conduct problems like ODD are strongly related to ADHD symptoms (Christiansen et al., 2008). Recent findings support the idea that the development of later conduct disorders in subjects with ADHD is mediated by co-morbid ODD (Biederman *et al.*, 2008b, Burke *et al.*, 2005, Lahey *et al.*, 2002, van Lier *et al.*, 2007). Furthermore, ODD seems to be a pivotal disorder for the development of conduct, affective and anxiety disorders in youth (Burke *et al.*, 2005, Nock *et al.*, 2007).

In mental health clinics, the diagnosis of ADHD and ODD in children and adolescents largely rests on detailed interviews with their parents and caretakers. In addition, parent and teacher rating scales like the Conners' Parent (CPRS; Conners *et al.*, 1998a) and Teacher Rating Scale (CTRS; Conners *et al.*, 1998b) or the Strength and Difficulties Questionnaire (SDQ; Goodman, 1997, 2001) contribute considerable information to the assessment process. Besides the narrowband syndrome scale of attention problems and hyperactivity, these instruments also include specific scales to screen for ODD (Conners, 1997, Goodman, 2001, Goodman *et al.*, 2000b).

The Conners' Parent Rating Scale (CPRS) and related versions of the CPRS have been used in previous studies as screening instruments for various mental disorders and as outcome parameters in treatment studies dealing with externalizing behavior problems including ADHD (for an overview see Gianarris *et al.*, 2001). Although the CPRS-R has been widely used in clinical and research settings, some quite fundamental criticisms have been

raised which primarily deal with the suitability of subscales measuring problems other than ADHD and, particularly, oppositional problems (Collett *et al.*, 2003).

In comparison to the CPRS-R, the SDQ is of more recent origin and is a shorter instrument for screening the most important mental disorders in childhood and adolescence. The SDQ addresses five narrowband syndromes: emotional symptoms, conduct problems, hyperactivity, peer problems and pro-social behavior. A computer algorithm has been developed for the prediction of oppositional-conduct, hyperactive-inattention, anxious-depressed or any psychiatric disorder. The predictions from the algorithm of the multi-informant SDQ has been found to correlate with clinical diagnoses of CD/ODD in referred subjects from Europe, Bangladesh and Australia (Goodman *et al.*, 2000c, Mathai *et al.*, 2004). High sensitivity in the detection of clinical CD/ODD has been established (86-93%) whereas specificity was only modest indicating that the SDQ was over-including subjects in these samples. On the other hand, in a community sample, a smaller number of subjects (68.2%) with internet-interview based diagnosis of CD/ODD (DAWBA; Goodman *et al.*, 2000a) were rated as having a probable diagnosis of CD/ODD based on the SDQ (Goodman *et al.*, 2000b). Due to the high rate of false positives, the SDQ seems to be more suitable for the screening rather than for the confirmation of diagnoses in community samples.

Only until recently, evidence has been missing that in contrast to other rating scales (e.g. the Child Behavior Checklist (CBCL); Biederman *et al.*, 2008a, Eiraldi *et al.*, 2000) both the parent SDQ (PSDQ) and the CPRS-R predict ODD in ADHD subjects. Furthermore, the CPRS-R oppositional scale (CPRS-R OPP) has never been specifically tested as regards its predictive validity for ODD. A recent study based on the IMAGE sample has analyzed these scales in the identification of conduct problems (Christiansen et al., 2008). This study found that the CPRS-R OPP and the PSDQ conduct problem scales (PSDQ CP) yielded the best discrimination of pure ADHD, ODD and CD. Additional ROC analyses confirmed adequate

diagnostic accuracy in the prediction of CD and found a cut-off-score above the 85th percentile as best discriminator for both scales. However, the prediction of ODD as a separate disorder apart from CD has not yet been analyzed in this study.

Therefore, as the first step for the present study we aimed to assess the predictive validity of the CPRS-R and the PSDQ in the prediction of ODD taking previous findings into account that confirmed ODD as a discrete psychiatric disorder regarding impairment and co-morbidity (Burke *et al.*, 2005, Greene *et al.*, 2002). Furthermore, cut-off analyses will be performed by quality efficiency statistics and the results of the PSDQ will be compared to the results of the proposed computer algorithm of the SDQ.

Different dimensions of ODD may by important regarding course and co-morbidity. The development of later emotional disorders may be predicted by the affective features in ODD symptoms reflecting negative and temperamental qualities (e.g. 'often angry and resentful' 'temper tantrums') (Burke et al., 2005). Recently, Stringaris and Goodman (in press-b) defined three *a priori* dimensions of oppositionality which were labeled ODD-irritable, ODD-headstrong and ODD-hurtful based on the DSM-IV criteria for ODD. The authors found different associations with other disorders in a large community sample of youth aged 5 to 16 years using parent and teacher information from a structured internet based diagnostic interview (Development and Well-Being Assessment; DAWBA) (Goodman *et al.*, 2000a). The ODD-irritable dimension was related to emotional disorders, whereas the ODD-headstrong dimension was related to ADHD and all three dimensions were related to conduct disorder. In a three-year-follow-up study, the longitudinal prediction of these ODD dimension was tested after controlling for initial psychopathology in a community sample (Stringaris and Goodman, in press-a). ODD irritable was found to be a predictor of generalized anxiety disorders and mood disorders, whereas ODD headstrong was the sole predictor of ADHD. Not as expected, among all three dimensions only the headstrong dimension was found

associated with the outcome of CD. However, the hurtful dimension was predicting aggressive CD symptoms. In conclusion, these findings suggest that ODD is a complex problem that may require differential clinical interventions according to the predominant dimension. Accordingly, the psychiatric assessment of ODD and its dimensions are of particular importance for clinical practice.

Therefore, the second aim of the present study was to test the construct validity of these three dimensions in a sample including ODD subjects. In contrast to Stringaris and Goodman (in press), the item “often deliberately annoys people” was assigned to the ODD-hurtful dimension because in a previous study this item was most strongly correlated with spiteful behavior (Speltz *et al.*, 1999). In a final step, the accuracy of the CPRS-R and the PSDQ in addressing these separate dimensions was tested in subjects with and without ODD.

Methods

Participants

The IMAGE study comprises 3229 offspring from 1187 fathers and 1341 mothers. Probands participating in the present study were European Caucasians aged 5-17 years that had been recruited in 12 child and adolescent psychiatry clinics representing eight countries: Belgium, Germany, Switzerland, Holland, Ireland, Israel, Spain and United Kingdom. Entry criteria for probands were a clinical diagnosis of ADHD based on DSM-IV criteria and access to one or both biological parents and one or more full siblings for DNA collection and clinical assessment. Exclusion criteria applying to both probands and siblings included autism, epilepsy, IQ < 70, brain disorders and any genetic or medical disorder associated with externalizing behaviors that might mimic ADHD.

The original sample of 1401 probands has been restricted to 1225 subjects with ADHD combined type. Furthermore 91 (7%) were excluded due to missing information on DSM-IV ODD criteria and another 31 (3%) subjects due to more than 10% missing items in the CPRS-R or the PSDQ. Thus, the final sample consisted of 1093 probands with a mean age of 10.8 years (SD 2.8 years). 956 subjects were male (87.5%) and 726 (66.4%) subjects from the present sample fulfilled DSM-IV criteria of ODD based on the PACS-interview (see below).

Measures

Diagnoses of ADHD and comorbid disorders were based on a standardized, semi-structured interview with the parents (Parental Account of Childhood Symptoms, [PACS]; Chen and Taylor, 2006, Taylor *et al.*, 1986). The PACS was developed for assessing ADHD and the most common child psychiatric disorder according to DSM-IV with good inter-rater reliability, predictive and discriminant validity and has been used in a number of epidemiological, genetic and interventional studies (Chen and Taylor, 2006, Leung *et al.*, 1996, Taylor *et al.*, 1991). The diagnoses of ADHD, ODD and CD were based on an algorithm which is appropriate for symptom count, age, time interval and impairment according to DSM-IV criteria. The interview was administered by skilled interviewers after advanced training..

The long form of the revised Conners' Parent Rating Scale (CPRS-R: L) consisting of 80 items was used in the present study. The CPRS-R is a reliable, accurate, and relatively brief measure of parental perceptions of children's disruptive behavior. Adequate psychometric properties have been confirmed (Conners, 1997, Conners *et al.*, 1998a) The seven syndrome scales (Cognitive Problems, Oppositional, Hyperactivity-Impulsivity, Anxious-Shy, Perfectionism, Social Problems and Psychosomatics), the ADHD index and the two sub-scales of the Conners'-Global Index (CGI; restless-impulsive, emotional lability) were included in the present study.

The SDQ is a brief behavioral screening questionnaire valid for 4 to 16 year olds. There are versions for adolescents (starting from 11 years onwards), parents and teachers. The SDQ consists of five syndrome scales (emotional symptoms, conduct problems, hyperactivity, peer problems and pro-social behavior) and can be obtained free via the internet (http://www.sdqinfo.com). Adequate psychometric properties of the scales have been documented (Goodman, 1997, 2001).

Analytic procedure

To study the diagnostic accuracy in the prediction of ODD, ROC analyses were performed separately for each CPRS-R syndrome scale including the two CGI subscales and the ADHD index scale. Furthermore, the PSDQ scales were included in the ROC analyses. The pro-social behavior scale was excluded because it does not address problem behavior. To compare different scales within the same sample, a critical z-ratio was calculated using a formula correcting for the non-independence of the scales (Hanley and McNeil, 1983). Finally, the optimal cut-off-score for the best scales was established: Efficiency (EFF) was calculated by the sum of true positives (TP) and true negatives (TN). In order to correct EFF for independence of the base rate (P) in the sample and to take into account the rate of a positive test result (Q), a quality index of efficiency was calculated using the following formula: d_Q = [EFF – PQ - (1 - P)(1 - Q)]/[1 - PQ- (1 - P)(1 - Q)] (Kraemer, 1992). In addition, the proposed computer algorithm for the identification of possible and probable CD/ODD cases was compared to the results based on the cut-off-score analyses.

Construct validity of the three ODD dimensions was analyzed by use of confirmatory factor analysis including all symptoms accounting for ODD in the PACS. Each symptom was rated as present or absent according to the corresponding PACS algorithm. Weighted least square

CFA of the tetrachoric correlation matrix of the DSM-IV criteria was used to test the three factor model and a conventional one-factor model of ODD (Brown, 2006). Three different recommended goodness of fit indicators (GFI) (Hair *et al.*, 2006) have been assessed using AMOS 16 software, i.e., the root mean square residual (RMR) as indicator of the unexplained co-variances of the model, the root mean square error of approximation (RMSEA) which includes a parsimony correction, and the comparative fit index (CFI) for evaluating the hypothesized model compared to a null model. Acceptance of any model was based on the following cut-offs: RMR < 0.05, RMSEA < 0.08 and CFI > 0.95 (Hu and Bentler, 1999, Marsh *et al.*, 2004).

In a further step, the prediction of the three factor structure of ODD by the CPRS-R and the PSDQ was analyzed. Backward linear regression analyses were performed including all syndrome and index scales of the CPRS-R and the PSDQ of subjects both with and without ODD. For these analyses, the total sample was split into two subgroups each, namely, prediction and cross-validation sub-samples. Group assignment was done by random sampling controlling for ODD, age and sex. When using exploratory analyses like backward linear regression, cross-validation can be a helpful technique in order not to over-interpret results in terms of generalizability (Leon *et al.*, 1996).

Results

Means and standard deviations of the CPRS-R scores and the PSDQ scores are shown in Table 1. Internal consistency as measured by Cronbach's alpha was .88 for the CPRS-R oppositional scale and .66 for the PSDQ CP. The scores of the two scales were strongly correlated ($r = .67$, $p < 0.001$).

Table 2 shows the results of the ROC - analyses for all CPRS-R syndrome scales and the PSDQ scales for predicting ODD. The CPRS-R oppositional scale showed the best prediction (AUC = .77) in contrast to all remaining CPRS-R scales. The PSDQ CP showed the best prediction (AUC = .73) in contrast to the remaining SDQ problem scales. The CPRS-R oppositional scale was superior when compared to the SDQ CP scale (z = 2.248, p = 0.014). There were no gender differences in the prediction of ODD by the CPRS-R OPP (boys AUC = .76; girls AUC = .79; z = -.63, p = 0.263) and for the PSDQ CP (boys AUC = .73; girls AUC = .75; z = -.34, p = 0.367).

The results of the cut-off analyses are shown in Table 3. For the CPRS-R OPP, a cut-off-score of 15 to 16 was established based on the quality index of efficiency (d_Q = .40). 73% of the subjects were classified correctly by this score. Sensitivity, specificity and positive and negative predictive power ranged between .58 and .80. For the PSDQ CP, the optimal cut-off-score was 5 (d_Q = .34). The corresponding sensitivity and specificity scores were in a similar range between .55 and .79. In addition, the point-biserial correlation coefficients were .44 (p< 0.001) between ODD and CPRS-R OPP, and .38 (p< 0.001) between ODD and the PSDQ CP.

As can be seen from table 3, the proposed computer algorithm for the SDQ in predicting *possible* CD/ODD resulted in equivalent results as those observed for the quality index efficiency score of .40 (SE = .73, SP = .55). Finally, the corresponding computer algorithm for *probable* CD/ODD, which considers the social impact of the symptoms, showed quite comparable efficiency with a reduced sensitivity score (.61) when compared to the specificity score (.75).

In the second part of the analyses, the three-factor-structure of the ODD was tested by confirmatory factor analysis with weighted least square statistics for the parameter

estimation. The factor structure and parameter estimates are shown in figure 1. Whereas the comparative fit indicator value was close to an acceptable level (CFI = .947) the other two GFI's suggested that the model had an excellent fit to the data (RMR =.006 and RMSEA = .041). The three dimensions as latent factors were correlated moderately to strongly. In particular the irritable and the headstrong dimension showed a strong correlation of .89. However, compared to the three factor solution a single factor model of ODD showed a decreased fit and according to the CFI an unacceptable fit to the present data (RMR =.010, RMSEA = .064 and CFI = .852).

Finally, backward linear regression analyses (probability level of F for entry = .001 and for removal = .01) separately for subjects with ODD (N = 726) and without ODD (N = 367) were performed in a prediction sub-sample (ODD: N= 363, non-ODD: N= 183) and cross-validated in a further sub-sample (ODD: N= 363, non-ODD: N= 184). The results for the prediction of ODD-irritable, ODD-headstrong and ODD-hurtful are shown in Table 4. All tested regression models were highly significant. The CPRS-R emotional lability scale (CPRS-R EL) significantly predicted ODD-irritable for subjects who did not fulfill criteria for ODD. A multivariate model including the CPRS-R EL and the CPRS-R OPP was found to significantly predict ODD-Irritable in subjects who fulfilled criteria for ODD. Both of these prediction models were confirmed in the cross-validation sub-sample as indicated by the comparable R-values ranging from .31 to .35. In the combined sample of subjects with and without ODD the correlations between CPRS-R EL and ODD-irritable amounted to r = .42 in the prediction sub-sample and r = .48 in the cross-validation sub-sample. For the ODD-headstrong dimension, no specific model resulting from backward regression analyses was confirmed in the cross-validation sample. This was true for both the ODD and the non-ODD condition. Finally, only the CPRS-R oppositional scale was found to predict the ODD-hurtful dimension in ODD (R = .27) and non ODD (R = .35) subjects. However, only in subjects with ODD (R =

.31) but not without ODD (R = .10) the prediction model was confirmed in the corresponding cross-validation sample.

Discussion

The first part of the present study dealt with testing the diagnostic accuracy of two common parent rating scales for predicting ODD in a sample of ADHD referred youth. Construct validity for three previous described dimensions of ODD were analyzed in the second part of the study. Finally, the diagnostic accuracy of the CPRS-R and p–SDQ in the prediction of these three dimensions of ODD was examined.

Diagnostic accuracy was tested by ROC leading to the calculation of the AUC. This measure of excellence in the prediction of diagnoses should be interpreted as follows: poor (50-.70); moderate to fair (.70-.80); good (.80-.90), and excellent (.90-1.00). Accordingly, the AUCs for CPRS-R OPP (.77) and PSDQ CP (.73) indicate an acceptable convergence of these scales with the diagnosis of ODD. These results are quite comparable with the diagnostic accuracy of the CBCL aggressive behavior scale in a pure ADHD sample (Biederman *et al.*, 2008a) and in a mixed ADHD sample with unreferred controls (Hudziak *et al.*, 2004).

In comparison to the present findings, higher AUCs based on parental ratings have been reported in the prediction of various psychiatric disorders other than ODD, e.g. for obsessive compulsive disorders (Hudziak et al., 2006) and for ADHD (Chen *et al.*, 1994). Furthermore, a better diagnostic accuracy has been found also in the in study by Christiansen et al. (2008) in the prediction of CD in ADHD subjects by the PSDQ CP and the CPRS-R OPP in a smaller subsample of the IMAGE study. The differences in diagnostic accuracy may be partly due to sample and rater effects. For instance, parent ratings of ODD and ADHD have been found to be biased by observer characteristics such as depressed mood and levels of stress

(van der Oord *et al.*, 2006). Thus, parents under stress or with depressed mood may experience ODD symptoms as particular aversive. However, whether or not the relationship with a child showing ODD is even more aversive for parents and may even more negatively influence diagnostic accuracy of ODD than in pure ADHD still has to be shown.

In contrast to the present findings, Biederman and colleagues (2008a) in their prediction of ODD in ADHD subjects by use of the CBCL found higher AUCs and efficiencies in girls than in boys. These results may be due to using standardized T-scores rather than raw scores.

In the present study, a cut-off-score of 15/16 on the CPRS-R oppositional problem scale and a cut-off-score of 4 on the PSDQ CP in the detection of ODD were found by quality efficiency statistics. For the CPRS-R, raw scores of 15/16 correspond to T-scores of 66-73 in boys and to 70-75 in girls. On the other hand a cut-off-score of T = 65 has been recommended for screening for ODD (Conners, 1997). Whereas this lower cut-off-score may be accurate in clinical settings the same score will be over-inclusive in an ADHD sample and particular for girls. However, the PSDQ computer algorithm for possible ODD/CD seems to work well in subjects with or without comorbid ADHD.

Whereas the recent studies by Stringaris and Goodman (Stringaris and Goodman, in press-a, b) focussed on the predictive validity of three theoretical established dimensions of ODD, the present study addressed the construct validity of these dimensions. By replicating the findings by Stringaris and Goodman, the present study serves as a cross-validation of the three ODD dimensions labeled ODD-irritable, ODD-headstrong and ODD-hurtful. The GFI results of the CFA convincingly show that a three factor structure of ODD is more appropriate than a single general factor of ODD. However, when considering the high correlation of r = .89 of ODD-irritable and ODD-headstrong (Figure 1) the differentiation of these two factors remains unclear. In consequence, the construct validity of three separate ODD dimensions

was not fully confirmed by the present data. Nevertheless, the present results show that ODD is a heterogeneous construct with ODD-hurtful as a separate dimension. This finding may have nosological implications for the upcoming DSM-V criteria. Furthermore, the strong correlation of ODD-irritable and ODD-headstrong may have its origins in the present ADHD sample. Thus, emotional self regulation deficits (Barkley, 1997) and delay aversion in ADHD (Castellanos *et al.*, 2006, Sonuga-Barke *et al.*, 2008) may strongly affect both ODD-irritable and ODD-headstrong. Further examination in a community sample is necessary to confirm the construct validity of ODD-irritable and ODD-headstrong.

Finally, potential predictors of these three dimensions were analyzed. Whereas the prediction of ODD-headstrong and ODD-hurtful by the CPRS-R and the PSDQ led only to ambiguous results, except for the CPRS-R OPP scale, the CPRS-R EL is a meaningful predictor of ODD-irritable. Furthermore, the CPRS-R EL predicted ODD-irritable also in subjects with no ODD indicating that this dimension is also important in pure ADHD subjects. Thus, the predictive validity of the CPRS-R EL originally found in both exploratory and confirmatory factor analyses (Parker *et al.*, 1996) was confirmed by the present results.

The present study addressed convergent validity across methods, i.e., diagnostic interview vs. rating scales. Despite the fact that the CPRS-R EL scale consists only of three items (i.e. temper outbursts, crying, mood changes), this scale is rather sensitive in predicting ODD-irritable as indicated by correlations ranging between r = .421 and r = .479. However, it is remarkable that only the item “temper outbursts” is part of both instruments, whereas the other two items do not overlap. Diagnostic accuracy of the CPRS-EL may be improved by considering additional items regarding DSM-IV ODD-irritable criteria.

Recently, the role of irritability in ADHD with comorbid ODD has been addressed in the context of severe mood dysregulation (SMD; Carlson, 2007). Next to abnormal mood, the

diagnostic criteria of SMD include symptoms which are similar to ADHD (e.g. distractibility, pressured speech) and a markedly increased reactivity to negative emotional stimuli (similar to ODD-irritable). Furthermore, Waschbusch et al. (2002) found increased anger expression and increased heart rate after mild provocation in a sample that was comorbid for ADHD/ODD but not in ADHD or ODD only subjects. Thus, the present results indicate that the construct of SMD is related to the ODD-Irritable dimension in ADHD subjects.

Furthermore, the ODD-irritable dimension has been found to be a strong predictor of future stress-related disorders, such as depression or generalized anxiety disorders. This association was independent of the presence of emotional disorders at the initial assessment (Stringaris and Goodman, in press-a). Thus, early assessment of ODD irritability by the CPRS-EL may help to administer appropriate prevention programs for stress-related disorders.

A previous study has found support for two separate but correlated constructs of ODD against adults and ODD against peers (Taylor *et al.*, 2006). Further studies may test ODD-dimensions in combination with the target of the oppositional behavior. It may be assumed that the headstrong dimension is associated with coercive parent-child interactions (Granic and Patterson, 2006) and may, therefore, be restricted predominantly to adults whereas the irritable and hurtful behaviors are more strongly associated with temperamental factors and may be independent of the provoking person.

Some limitations of the present findings have to be mentioned. First, the present results were based on a referred ADHD sample and may not generalize to other community and clinical samples with different base rates and characteristics of ODD. Secondly, the results were limited to Caucasian subjects only. In addition, the present results can hardly be generalized to females because the sample consisted mostly of male subjects. Finally, the present

findings are based on parental ratings of ODD. Multi-informant diagnostic criteria might shed further light on the prediction of these ODD dimensions.

In summary, both the PSDQ including the recommended computer algorithm and the CPRS-R with the suggested cut-off-scores can be recommended for clinical assessment of ODD. In clinical practice, lower cut-of scores may be chosen to increase sensitivity and by taking into account the higher costs for missing true cases. However, additional assessments may be necessary regarding onset, duration and impact of the symptoms to improve diagnostic efficiency. For clinicians, the three dimensions of ODD can be helpful for a better understanding of the disorder. Accordingly, the CPRS-R EL scale may help to detect irritability symptoms in ADHD subjects with and without comorbid ODD. These procedures may be important for treatment planning because next to ADHD therapy additional training of emotional skills or stress prevention is useful. However, the diagnostic assessment of the ODD-hurtful and ODD-headstrong dimensions with the present rating scales is still limited and further studies involving other diagnostic instruments are warranted.

Declaration of interests

Tobias Banaschewski, Jan Buitelaar, Joseph Seargent, Edmund Sonuga-Barke, Margaret Thompson and Hans-Christoph Steinhausen have been a consultant, speaker or member of the advisory board of Bioproject, Bristol-Myer Squibb, Eli Lilly, Flynn Pharma, Janssen-Cilag, Medice, Novartis, Organon, Pfizer, Servier, Shire and/or UCB.

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Table 1. Means and standard deviations (raw scores) of CPRS-R and the PSDQ separate for subjects with and without co-morbid ODD in the entire sample, in the prediction sample and the cross-validation sub-sample

Sample	Entire sample (N = 1093)				Prediction sub-sample (N = 546)				Cross-validation sub-sample (N =547)			
	ODD (N = 726)		no ODD (N = 367)		ODD (N = 363)		no ODD (N = 183)		ODD (N = 363)		no ODD (N = 184)	
	means	SD	means	SD	means	SD	means	SD	means	SD	means	SD
Age	10.83	2.71	10.65	2.83	10.86	2.61	10.61	2.96	10.80	2.81	10.68	2.71
CPRS-R Syndrome Scales												
Oppositional	19.41	5.89	13.06	6.49	19.63	5.70	13.05	6.35	19.20	6.07	13.07	6.65
Cognitive Problems / Inattention	24.70	6.51	23.38	6.73	25.05	6.27	23.13	6.01	24.35	6.74	23.64	7.38
Hyperactivity	17.76	5.12	16.10	5.84	17.91	4.98	16.14	5.53	17.62	5.26	16.05	6.16
Anxious-Shy	6.59	5.12	4.73	4.55	6.80	5.12	4.72	4.75	6.38	5.13	4.74	4.36
Perfectionism	6.29	4.67	5.06	4.26	6.27	4.68	4.93	4.21	6.31	4.66	5.18	4.31
Social Problems	6.10	4.02	4.37	3.54	6.09	4.03	4.36	3.42	6.10	4.01	4.39	3.66
Psychosomatic	4.43	3.98	3.22	3.43	4.63	3.95	3.04	3.20	4.23	4.02	3.39	3.64
ADHD Index	27.72	5.67	25.83	6.35	27.91	5.64	25.74	5.75	27.53	5.70	25.91	6.91
CGI: Restless-Impulsive	16.21	3.41	14.25	4.03	16.21	3.43	14.44	3.73	16.21	3.40	14.06	4.30
CGI: Emotional Lability	5.28	2.16	3.55	2.36	5.45	2.17	3.55	2.30	5.11	2.14	3.55	2.42
PSDQ Scales												
Emotional Symptoms	4.16	2.51	3.25	2.43	4.22	2.46	3.25	2.46	4.08	2.57	3.22	2.40
Conduct Problems	5.34	2.18	3.43	2.17	5.47	2.15	3.38	2.04	5.21	2.21	3.47	2.29
Hyperactivity	8.58	1.56	8.31	1.82	8.69	1.53	8.43	1.76	8.47	1.58	8.18	1.88
Peer Problems	4.32	2.60	3.37	2.57	4.23	2.57	3.42	2.51	4.42	2.64	3.32	2.65

Note. All values a raw scores.

Table 2. ROC analysis findings with area under the curve (AUC) of the CPRS-R and the PSDQ problem syndrome scales

Sample (N = 1093)	**AUC**	**SE**	**p**
CPRS-R problem syndrome scales			**Deviation from CPRS-R Oppositional**
Oppositional	.77	.015	--
Cognitive Problems / Inattention	.56	.018	< 0.001
Hyperactivity	.58	.018	< 0.001
Anxious-Shy	.61	.018	< 0.001
Perfectionism	.58	.018	< 0.001
Social Problems	.63	.018	< 0.001
Psychosomatic	.59	.018	< 0.001
ADHD Index	.59	.018	< 0.001
CGI: Restless-Impulsive	.64	.018	< 0.001
CGI: Emotional Lability	.71	.017	< 0.001
PSDQ problem syndrome scales			**Deviation from PSDQ Conduct Problems**
Emotional Symptoms	.61	.018	< 0.001
Conduct Problems	.73	.016	--
Hyperactivity	.53	.019	< 0.001
Peer Problems	.61	.018	< 0.001

Note. All scales showed significant deviance of AUC from random prediction (AUC = .5) except the PSDQ hyperactivity scale (p=0.07).

Table 3. Cut-off-score analyses of the CPRS-R oppositional scale and the PSDQ CP by a quality efficiency indicator (d_Q)

Cut-off-score/ Computer algorithm	Base rates	SE	SP	PPP	NPP	EFF	d_Q	LR +	LR-
CPRS-R oppositional scale									
10	0.86	0.94	0.31	0.73	0.73	0.73	0.29	1.36	-2.03
11	0.83	0.92	0.36	0.74	0.70	0.73	0.32	1.45	-1.55
12	0.80	0.91	0.41	0.75	0.69	0.74	0.35	1.54	-1.22
13	0.76	0.88	0.47	0.77	0.67	0.74	0.38	1.67	-0.87
14	0.72	0.84	0.53	0.78	0.63	0.74	0.38	1.78	-0.60
15	**0.66**	**0.79**	**0.61**	**0.80**	**0.60**	**0.73**	**0.40**	**0.10**	**0.39**
16	**0.62**	**0.76**	**0.65**	**0.81**	**0.58**	**0.72**	**0.40**	**0.08**	**0.38**
17	0.56	0.70	0.70	0.82	0.54	0.70	0.37	2.32	0.01
18	0.51	0.64	0.74	0.83	0.51	0.68	0.35	2.50	0.14
19	0.45	0.57	0.80	0.85	0.49	0.65	0.32	2.85	0.28
20	0.39	0.51	0.83	0.86	0.46	0.62	0.28	3.00	0.39
21	0.35	0.45	0.86	0.87	0.44	0.59	0.25	3.26	0.47
Parent SDQ conduct problem scale									
1	0.97	0.99	0.08	0.68	0.78	0.68	0.08	1.07	-11.96
2	0.91	0.96	0.19	0.70	0.71	0.70	0.18	1.19	-4.03
3	0.81	0.90	0.38	0.74	0.67	0.73	0.32	1.47	-1.35
4	**0.68**	**0.79**	**0.55**	**0.78**	**0.57**	**0.71**	**0.34**	**1.75**	**-0.45**
5	0.52	0.64	0.71	0.82	0.50	0.66	0.32	2.23	0.11
6	0.38	0.47	0.82	0.84	0.44	0.59	0.24	2.60	0.42
7	0.24	0.31	0.90	0.87	0.40	0.51	0.17	3.28	0.65
8	0.13	0.17	0.95	0.87	0.37	0.43	0.09	3.38	0.82
9	0.06	0.08	0.98	0.90	0.35	0.38	0.04	4.63	0.92
PSDQ computer algorithm for CD/ODD									
Possible CD/ODD disorder	0.68	0.79	0.55	0.78	0.57	0.71	0.34	0.11	0.35
Probable CD/ODD disorder	0.49	0.61	0.75	0.83	0.50	0.66	0.32	0.03	0.27

Note. SP = specificity; SE = sensitivity; PPP = positive predictive power; NPP = negative predictive power; EFF = efficiency; d_Q = quality index for efficiency; LR+ = likelihood ratio of a positive test; LR- = likelihood ratio of a negative test.

Table 4. Prediction of ODD-dimensions by the PSDQ problem scales, the CPRS-R problem and index scales based on backward linear regression analyses in the prediction sample separate for subjects with and without ODD

Prediction model	Model summary		ANOVA			Coefficients		
	R (prediction sample)	R (cross-validation sample)	Df	F	Sign.	Beta	T	Sign.
ODD diagnosis								
ODD-Irritable	.345	.326	2	24.29	.000			
CPRS-R oppositional behavior						.179	2.77	.006
CPRS-R CGI emotional lability						.201	3.11	.002
ODD-Headstrong	.261	.125	2	13.18	.000			
CPRS-R oppositional behavior						.153	2.77	.006
CPRS-R ADHD Index						.159	2.87	.004
ODD-Hurtful	.268	.314	1	28.03	.000			
CPRS-R oppositional behavior						.268	5.29	.000
No ODD diagnosis								
ODD-Irritable	.340	.311	1	23.71	.000			
CPRS-R CGI emotional lability						.340	4.87	.001
ODD-Headstrong	.377	.239	2	14.91	.000			
CPRS-R oppositional behavior						.439	5.55	.001
CPRS-R CGI restless impulsive						-2.12	-2.63	.009
ODD-Hurtful	.348	.097	1	25.01	.000			
CPRS-R oppositional behavior						.348	5.00	.000

Note. Beta = standardized regression coefficent. Prediction sample with ODD: N = 363; cross-validation sample with ODD: N = 363; prediction sample without ODD: N = 183; cross-validation sample without ODD: N = 184.

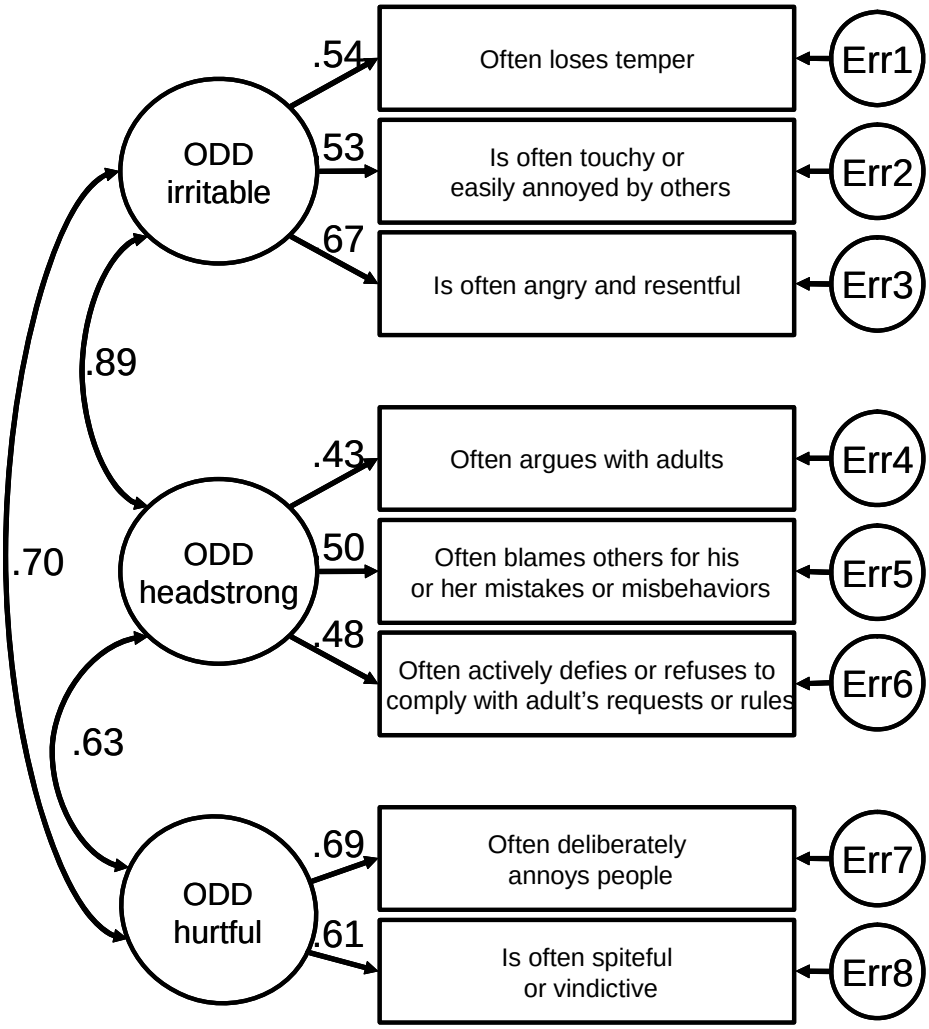

Figure 1. Confirmatory factor analysis of the 8 DSM-IV ODD criteria. Standardized regression weights and correlations between the three ODD factors ODD-Irritable, ODD-Headstrong and ODD-Hurtful.