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# Cognitive Functioning and Family Risk Factors in Relation to Symptom Behaviors of ADHD and ODD in Adolescents

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**Abstract**

**Objective:** In this study, the authors investigated whether ADHD and oppositional defiant disorder (ODD) behaviors share associations with problems in cognitive functioning and/or family risk factors in adolescence. This was done by examining independent as well as specific associations of cognitive functioning and family risk factors with ADHD and ODD behaviors. **Method:** A sample of 120 adolescents from the general population was assessed on various cognitive tasks. ADHD and ODD behaviors were measured through parental and teacher ratings based on *Diagnostic and Statistical Manual of Mental Disorders* (4th edition) criteria. Parents and adolescents provided information regarding measures of family risk factors. **Results:** The results show that only cognitive functioning was associated with ADHD behaviors, and family risk factors were, independent of cognitive functioning, associated with ODD behaviors. **Conclusion:** These results suggest that cognitive performance bears a specific significance for ADHD behaviors, whereas family risk factors have specific importance for ODD behaviors. (*J. of Att. Dis. 2010; XX(X) 1-XX*)

**Keywords**

cognitive functioning, family risk factors, ADHD, oppositional defiant disorder

Externalizing behavioral problems, such as inattention, hyperactivity/impulsivity, and defiant behavior, are continuously expressed in a population (e.g., Nadder, Rutter, Silberg, Maes, & Eaves, 2002). These behavioral problems commonly co-occur (Green et al., 2002), and research has shown that high levels of externalizing problems in adolescence are related to risk-taking behavior and difficulties in everyday life (e.g., Whalen, Jamner, Henker, Delfino, & Lozano, 2002). At their extreme end, inattentive (IA) and hyperactive/impulsive (H/I) behaviors are characteristic for ADHD, and defiant behavior is characteristic for oppositional defiant disorder (ODD; American Psychiatric Association [APA], 1994). The development and maintenance of both ADHD and ODD behaviors have been related to poor cognitive functioning and family risk factors (e.g., Mathijssen, Koot, & Verhulst, 1999; Nigg, 2006). Thus, interesting questions concern (a) to what extent cognitive functioning and family risk factors, independently of one another, are related to ADHD and/or ODD behaviors? and (b) whether there are specific associations between poor cognitive functioning and/or family risk factors and the two types of problem behaviors? To further understand these problem behaviors, research using a dimensional approach, rather than a categorical approach, is of importance as it examines a broader range of behavioral symptoms.

## Cognitive Functioning in Relation to ADHD and ODD Behaviors

Much of the research on cognitive functioning in relation to ADHD and ODD behaviors has focused on executive functioning (EF; for example, Burke, Loeber, & Birmaher, 2002; Coghill, Nigg, Rothenberger, Sonuga-Barke, & Tannock, 2005). EF is defined as cognitive abilities that enable goal-oriented thoughts and actions, such as working memory (WM), inhibition, and the ability to flexibly shift focus of attention (Pennington & Ozonoff, 1996). WM is the ability

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to hold information in mind and manipulate it (Baddeley, 2000). Inhibition is the ability to ignore distraction or to suppress a prepotent response (Friedman & Miyake, 2004). There are relatively few studies that have examined EF in relation to ODD symptoms specifically. Indirect support for such an association comes from studies on physical aggression or on ODD combined with conduct disorder (Moffit, 1993; Séguin, Boulerice, Harden, Tremblay, & Pihl, 1999). Within the ADHD literature, meta-analyses have found impairments in WM and inhibition to be of importance (Martinussen, Hayeden, Hogg-Johnson, & Tannock, 2005; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), although not all individuals with ADHD have been found to have an EF deficit (Willcutt et al., 2005).

Studies that have examined EF in relation to both ADHD and ODD, within the same study, are rather scarce and mainly based on clinical samples. Research on clinical samples, consisting of preschool children, school-aged children, and adolescents, suggest that EF deficits are primarily associated with ADHD (Clark, Prior, & Kinsella, 2000; Kalff et al., 2002; Klorman et al., 1999; van Goozen et al., 2004). Further support for EF deficits being primarily related to ADHD symptoms comes from studies that have controlled dimensionally for symptoms of ODD when studying EF in ADHD and vice versa. In two preschool samples, ADHD symptoms, but not ODD symptoms, were associated with EF deficits (Brocki, Nyberg, Thorell, & Bohlin, 2007; Thorell & Wåhlstedt, 2006). Similarly, Oosterlaan, Scheres, and Sergeant (2005) found that EF deficits were associated with ADHD symptoms, independently of ODD symptoms, in school-aged children. These findings, from studies that have controlled for ADHD and ODD symptoms, respectively, are yet to be replicated in studies of adolescents.

Several researchers have argued that it is important to include a broader measure of cognitive functions in studies on ADHD and ODD behaviors (e.g., Burke et al., 2002; Coghill et al., 2005). There are some studies on ADHD that apart from EF measures have included measures related to the regulation of arousal and activation. Measures of arousal and activation commonly consist of mean reaction time (MRT) and reaction time (RT) variability on cognitive tasks. Slower and more variable response speed on RT tasks has been frequently associated with ADHD (e.g., Castellanos et al., 2005; Kuntsi, Oosterlaan, & Stevenson, 2001). High RT variability has also been reported to characterize children with aggressive behavior (Oosterlaan & Sergeant, 1996, 1998). In one of the few studies, Scheres, Oosterlaan, and Sergeant (2001) compared performance on various cognitive functions in groups of children diagnosed with ADHD, ODD, and controls. The groups did not differ in terms of inhibition control, but the groups with ADHD only, ODD only, and ADHD with comorbid ODD were all found to have slower and more variable response speeds compared with did controls. However, given the high co-occurrence of ADHD and ODD symptoms, it is possible that subclinical levels of ADHD symptoms accounted for the associations with ODD; this was not addressed in the earlier study.

An additional aspect to consider is whether both symptom scales of ADHD (i.e., IA and H/I) can be distinguished from ODD symptoms in terms of cognitive functioning. Some authors have suggested that problems in cognitive functioning are more strongly related to the IA symptom scale of ADHD (Chhabildas, Pennington, & Willcutt, 2001; Lui & Tannock, 2007), whereas others have found few or no differences (Nigg, Blaskey, Huang-Pollock, & Rappley, 2002; Solanto et al., 2007). It has also been proposed that the H/I symptom scale is more strongly associated with ODD than the IA symptom scale (Loeber, Burke, Lahey, Winters, & Zera, 2000). Thus, studies are needed that examine the specificity of cognitive functioning in relation to the symptom scales of IA, H/I, and ODD behaviors.

## Family Risk Factors in Relation to ADHD and ODD

Family risk factors have been found to play an important role in the onset (Sandberg, Rutter, Pickles, McGuinnes, & Angold, 2001) and continued manifestation (Mathijssen et al., 1999) of more broadly defined externalizing problem behavior. One important family risk factor is low socioeconomic status (SES), which has been related to both behavioral problems and poor cognitive functioning in children and adults (Conger & Donnellan, 2007). Apart from low SES, stressful life events and a chaotic home environment can be viewed as universal risk factors for the development of problem behaviors (Biederman, 2005; Pike, Iervolino, Eley, Price, & Plomin, 2006). These risk factors could exacerbate difficulties in children and adolescents who already exhibited problem behaviors (Mathijssen et al., 1999) or function as additive risk factors in the onset of externalizing problems (Burke et al., 2002).

Studies that have examined family risk factors in relation to either ADHD or ODD have found associations with both disorders. Regarding ODD behavior, particularly family dysfunction and low income have been pointed out in many studies as being significant risk factors for its development (Earls & Mezzacappa, 2002). In a study by Green and colleagues (2002), ODD was associated with adverse family environment even after controlling for other comorbid disorders (e.g., conduct disorder, ADHD, depression, and bipolar disorder). Within ADHD research, studies based on both clinical and community samples of school-aged children have shown that ADHD behaviors are associated with low SES, high occurrence of stressful events, and parental marital conflict (Biederman, Faraone, & Monuteaux, 2002; Counts, Nigg, Stawicki, Rappley, & Von Eye, 2005; Scahill et al., 1999). One recent study found that family risk factors were associated with ADHD behaviors over and above cognitive functioning in both children and adolescents (Forssman et al., 2009). Currently, it is not clear whether that finding also extends to adolescents with ODD behaviors.

Studies on psychosocial adversity that have examined both ADHD and ODD within the same study have reached somewhat inconsistent conclusions. Counts et al. (2005) found that ADHD was associated with family adversity (e.g., low SES, marital conflict, and stressful events), independent of disruptive behaviors (ODD and CD), and that family adversity gave unique contributions to disruptive behaviors. In contrast, two other studies found poorer family functioning to be associated with ODD, rather than ADHD, in preschool (Cunningham & Boyle, 2002) and adolescence (Rey, Walter, Plapp, & Denshire, 2000). An important difference between these studies is that only the study by Counts et al. controlled for ADHD and disruptive behavior. In summary, there are links in the research on family risk factors with both ADHD and ODD behaviors, although few studies have examined specific associations to these symptoms.

## The Present Study

This study investigated the extent to which behaviors of ADHD (i.e., IA and H/I) and ODD share associations with cognitive and/or family risk factors in adolescents from the general population. We employed a dimensional approach to be able to examine a broader range of ADHD and ODD behaviors and their associations. The goals of the study were

1. to examine whether cognitive functioning and family risk factors were independently associated with ADHD and ODD behaviors, respectively.
2. to examine the specificity of risk factors in relation to each type of problem behavior by controlling dimensionally for ADHD behaviors when studying ODD behaviors and vice versa. If ADHD and ODD behaviors are found to share associations with cognitive functioning and/or family risk factors, then this association could explain their high co-occurrence and thereby contribute to our understanding of the etiological relationships between the two behavioral problems.

On the basis of previous findings, we predicted that the behavioral dimensions of ADHD, but not ODD, would primarily be associated with poor cognitive functioning. As the research on ADHD and ODD behaviors in relation to family risk factors is inconclusive, we had no a priori predictions regarding this issue. Contributions of family risk factors to ADHD and/or ODD behaviors could point toward possible nongenetic causes of the two problem behaviors.

## Method

### *Sample and Procedure*

A description of the sample and measures can be found in Table 1. The participants consisted of 120 adolescents (50% girls) who were in the age range 12.69 to 16.33 years ($M$ = 14.76; $SD$ = 0.89). Sixteen adolescents had missing data on measures of family risk factors because parents did not provide this information. Four adolescents had missing data on some cognitive measures due to error on part of the investigator. Adolescents with missing data did not differ from the rest of the sample on any of the measured variables in the analyses. The adolescents were all enrolled in regular classes and were recruited from five schools located in a university city and two smaller towns in the mid-eastern part of Sweden. Recruitment was initiated by obtaining verbal consent from school principals and teachers. Written consent was given by parents, and prior to assessment, verbal assent was also given by the adolescents. The assessment took place in a quiet room at each school and lasted for approximately 1 hr 30 min. Adolescents, teachers, and parents filled out questionnaires concerning adolescents' behaviors and family factors.

### *Measures*

*ADHD and ODD behaviors.* ADHD and ODD behaviors were rated on a 4-point scale, ranging from 0 (*never/seldom*) to 3 (*very often*), by parents and teachers using the 18 symptoms of ADHD (nine items for the IA subscale and nine items for the H/I subscale) and the 8 symptoms of ODD as they appear in the *Diagnostic and Statistical Manual of Mental Disorders* (4th edition; *DSM-IV*; APA, 1994). To cover a broader spectrum of the adolescents' environment, we averaged the parent and teachers' mean values on each scale. Correlations between teacher and parent ratings for IA behaviors, H/I behaviors, and ODD behaviors were as follows: $r = .43$, $p < .00$; $r = .27$, $p < .01$; and $r = .31$, $p < .01$, respectively.

### *Cognitive Functions*

*WM*. WM was assessed using three measures: children's size-ordering task (CSOT; McInerney, Hramok, & Kerns, 2005), counting span task (Case, Kurland, & Goldberg, 1982), and a visuospatial WM task (Tillman, Nyberg, & Bohlin, 2008).

The CSOT has been found to be a valid measure of WM and has been applied to both clinical and normal populations (McInerney et al., 2005). A previous study (Tillman, Eninger, Forssman, & Bohlin, 2010) has reported adequate split-half reliability for this task, .63. In the current study, it was used as a verbal WM task in which words that represent common

**Table 1.** Description of Measures

| | *M* | *SD* | Range | Minimum-maximum range |
|---|---|---|---|---|
| ADHD/ODD symptom behaviors | | | | |
| ADHD–IA | 0.67 | 0.56 | 0.00-2.44 | 0.00-3.00 |
| ADHD–H/I | 0.33 | 0.39 | 0.00-2.06 | 0.00-3.00 |
| ODD | 0.34 | 0.39 | 0.00-2.06 | 0.00-3.00 |
| Cognitive functions | | | | |
| Working memory[a] | 0.00 | 0.76 | −1.51-2.28 | |
| CSOT | 24.58 | 5.25 | 11-37 | 0-42 |
| Counting span | 26.32 | 11.89 | 5-72 | 0-81 |
| Visuospatial working memory | 19.20 | 8.76 | 2-42 | 0-45 |
| Interference control | 0.04 | 0.04 | −.12-.27 | |
| Response inhibition | 3.08 | 2.86 | 0-18 | 0-25 |
| Mean reaction time | 0.44 | 0.05 | .33-.57 | |
| Reaction time variability | 0.08 | 0.03 | .04-.27 | |
| Nonverbal intelligence | 43.13 | 8.33 | 12-56 | 0-60 |
| Family factors | | | | |
| Parent's educational level | 3.20 | 1.16 | 1-5 | 1-5 |
| Chaos | 1.97 | 0.52 | 1-3.27 | 1-5 |
| Life events | 0.11 | 0.12 | 0.00-.57 | 0.00-1.00 |
| Adversity index | 0.20 | 0.24 | 0.00-1.0 | 0.00-1.00 |

Note: ODD = oppositional defiant disorder; IA = inattention; H/I = hyperactive-impulsive; CSOT = children's size-ordering task.
[a] Working memory is the standardized measure of the three working memory tasks.

objects were read to the participants by the investigator. The participants were asked to verbally reproduce the objects in order of size from smallest to largest (e.g., apple, horse). The trials became gradually more difficult as list length was increased from two objects up to seven objects. There were two trials per list length. The maximum score on this test was 42, that is, one point for each pair of words presented in the correct order. The test was terminated when participants scored zero on two trials of the same list length.

The counting span is a widely used, reliable, and valid test of verbal WM, and estimates of coefficient alphas and split-half reliabilities are typically in the range of .70 to .90 (Conway et al., 2005). Participants were presented with displays on a computer consisting of arrays of blue squares and red circles on a white background. They were instructed to count red circles aloud, while pointing at each, and to remember the numbers counted in correct order for later recall. A number of displays were presented in a sequence, and at the end of a sequence the participants recalled the numbers. The participants performed two practice trials before the onset of the test. At the first level of the test, there were two displays in a sequence and the number of displays increased with one display for each level, with seven displays at the highest level. At each level there were three trials, and the test ended when the participant failed to correctly recall all numbers on two or three trials at the same level. A correct response was the answer produced by the participant when counting, not necessarily the actual number of red circles. The maximum score on this test is 81, which is one point for each correct answer on each trial.

The visuospatial WM task is a newly developed measure. Performance on this task has been found to be related to short-term memory, verbal WM, and intelligence (Tillman et al., 2008), indicating the validity of this task. Adequate split-half reliability of .72 for this task has been reported by Tillman (2008). In this task, beach balls of different sizes (from 0.4 cm to 2.0 cm in diameter) are presented, one by one, for 1,000 ms on a screen with blank intervals of 1,000 ms between them. The participants were told that they were to recall the location of each beach ball and their order of appearance in size, starting from the smallest. After each trial, the participant indicated each location with the computer mouse. On the first level of the task, the participants were to remember two locations and their order of size, and the task ended at Level 5 with a maximum of six locations. Each level consisted of three trials and to continue to the next level the participant had to correctly locate a minimum of 30% locations on each trial. The maximum score on this test is 45, which corresponds to one score for each consecutive pair of locations marked in correct order.

To achieve a measure of WM with equal weights of verbal and visuospatial WM, we aggregated the average of the two standardized verbal WM measures (CSOT and counting span task) with the standardized measure of visuospatial

WM. Correlations from CSOT to the counting span task and visuospatial WM were as follows: $r = .45$, $p < .001$, and $r = .36$, $p < .001$, respectively. The correlation between counting span task and visuospatial WM was $r = .26$, $p < .01$.

*Interference control*. As a measure of interference control, we used a child version of the conflict measure (Rueda et al., 2004) that is based on the widely used Flanker task (Eriksen & Eriksen, 1974).Test-retest reliability of this task (.77) has been demonstrated to be adequate (Fan, McCandliss, Sommer, Raz, & Posner, 2002). In this task, the participants were instructed to indicate the direction of a center fish that was surrounded by four other fish, which are distractors, by pushing a button to the left or right. The distractors were pointing either in the same directions as the target (congruent conditions, 50%) or in the opposite direction (incongruent conditions). The target was presented on a screen for 1,500 ms with an Interstimulus Interval (ISI) of 3,500 ms in 48 trials. The participants began with a practice block when it was clear that they had understood the instructions. The practice block took approximately 1 min and the test block took approximately 3 min. Interference control was calculated by subtracting the MRT of hits on congruent trials from the MRT of hits on incongruent trials.

*Response inhibition*. As a measure of response inhibition, we used a computerized go/no-go task that is based on the go/no-go paradigm, which has been widely used in ADHD research (Trommer, Trommer, Hoeppner, Lorber, & Armstrong, 1988). The participants were presented with five different figures, one at a time, and were instructed to press a key every time they saw a figure on the screen, except when the figure was a triangle. Before the onset of this task, the participants performed a practice block, which consisted of 15 trials. The task consisted of 100 trials, and the no-go figure was presented on 25% of the trials. Each figure was presented on the screen for 750 ms with an ISI of 3,500 ms. We used the number of commission errors in the go/no-go task as a measure of response inhibition. The split-half reliability for commission errors was found to be .74.

*Response speed*. The measure of response speed consisted of the MRT to hits on go stimuli from the go/no-go task described above. The split-half reliability for RT on go stimuli was found to be .98.

*Response variability*. As a measure of response variability, we used the standard deviation of RT to hits on go stimuli from the go/no-go task described earlier.

*Intelligence*. Intelligence was measured by Raven's Progressive Matrices (Raven, Court, & Raven, 1977). The Raven's Progressive Matrices is a reliable measure of nonverbal, fluid, intelligence in children and adults, with test-retest reliabilities ranging from .88 to .93 and internal consistencies ranging from 0.97 to 1.00 in the ages studied here (Raven, Court, & Raven, 1992). This test has five sections (A, B, C, D, & E) with 12 problems to solve in each section. The problems consist of incomplete pictures of abstract figures (e.g., shapes, lines) or patterns and the participants are instructed to choose one among six (Sections A and B) or eight (Sections C, D, and E) figures that fits best with the whole picture. This test was always presented last in the assessment and had no time limit. The maximum obtained score in this test is 60. We used intelligence as a control measure as it is a common procedure to report results both with and without controlling for IQ.

## Family Risk Factors

*Parent's education*. Parents provided information about the highest level of education completed by each parent from a list of five educational levels (1 = *9 years or less of schooling*, 2 = *high school—vocational training*, 3 = *high school—theoretical education*, 4 = *education after high school—not college/university*, and 5 = *college/university*). The levels of education from both parents were aggregated into one measure.

*Chaos*. Parents and the participants rated the degree of chaos in the home on the Confusion, Hubbub, and Order Scale (Chaos). This is a scale that has been found to have adequate test-retest reliability (.79) and has been found to correspond well with observed environmental conditions (Matheny, Wachs, Ludwig, & Phillips, 1995). This scale consists of 15 items that concern levels of commotion, routines, and noise (e.g., "No matter how hard we try, we always seem to be running late"). Items were rated on a scale from 1 to 5, where higher values indicated more chaos in the home environment. The mean values from the participants' and their parents' ratings were aggregated into one measure. The correlation between parent and adolescent ratings was $r = .53$, $p < .001$.

*Life events*. The Life Event Scale was adapted from the Life Event Questionnaire for Adolescents, which is an instrument that has been found to be negatively associated with adjustment in adolescence (Masten, Neemann, & Andenas, 1994). Parents provided yes or no answers to the occurrence of 15 life events during the past 2 years that were beyond their child's control (e.g., moving to a new house, death of close family member, and separation of parents). We used the mean score from this scale where a higher value indicates more life event–related stress in the participants' lives.

*Adversity index*. On the basis of parental reports, an adversity index ranging from 0 to 4 was created in an approach inspired by but not identical to Counts and colleagues (2005). In this index, one point was given for the presence of each of the following: nonintact family structure (reconstructed family or single-parent household), economic difficulties (difficulties paying for necessary household expenses, for example, food or rent, during the past 2 years), large sibship (3 or more siblings), and parental unemployment/sick

**Table 2.** Pearson Correlations Between Dependent Variables and Predictors ($N$ = 104-120)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADHD/ODD symptom behaviors | | | | | | | | | | | | | |
| 1. ADHD–IA | | .68*** | .65*** | −.29** | .27** | .00 | .25** | .43*** | .18 | .27** | −.21* | .15 | −.22* |
| 2. ADHD–H/I | | | .63*** | −.12 | .12 | −.05 | .21* | .38*** | .12 | .16 | −.21* | .06 | −.09 |
| 3. ODD | | | | −.09 | .08 | −.07 | .22* | .28** | .30** | .43*** | −.21* | .28** | −.10 |
| Cognitive functions | | | | | | | | | | | | | |
| 4. Working memory | | | | | −.19* | −.06 | −.41*** | −.33*** | .22* | .17 | .13 | .07 | .37*** |
| 5. Interference control | | | | | | .14 | .18 | .44*** | .02 | .02 | −.09 | −.03 | −.20* |
| 6. Response inhibition | | | | | | | −.25** | .28** | .04 | −.00 | −.04 | .12 | −.00 |
| 7. Mean reaction time | | | | | | | | .57*** | −.03 | −.02 | −.21* | .04 | −.27** |
| 8. Reaction time variability | | | | | | | | | .10 | .07 | −.26** | .17 | −.31** |
| Family factors | | | | | | | | | | | | | |
| 9. Chaos | | | | | | | | | | .43*** | −.06 | .23* | −.03 |
| 10. Life events | | | | | | | | | | | −.19 | .59*** | −.03 |
| 11. Parent's education | | | | | | | | | | | | −.21* | .05 |
| 12. Adversity index | | | | | | | | | | | | | −.08 |
| Intelligence | | | | | | | | | | | | | |
| 13. Nonverbal intelligence | | | | | | | | | | | | | |

Note: ODD = oppositional defiant disorder; IA = inattention; H/I = hyperactive-impulsive.
*$p$ < .05. **$p$ < .01. ***$p$ < .00.

leave (one parent or both being primarily unemployed or on sick leave from work). The mean value from this index was employed in the analyses.

### *Data Analyses*

The main analyses consisted of hierarchical linear regression models where the dependent variables were the two behavioral symptom subscales of ADHD (IA and H/I) and the ODD behavioral symptom scale. To be included in the regression analyses, the cognitive and family risk variables had to be correlated with at least one of the dependent variables. The cognitive and family risk variables were entered in blocks in the first or second step, alternately, and we examined the $\Delta R^2$ for each block. A significant effect of a block of measures in the first step indicates that the block of measures contributes to the outcome. A significant contribution in the second step indicates that the block of measures contributes independent of the first block, provided that the block entered in the first step is also significant. An effect that is significant in the first but not in the second step indicates shared variance between variables in the two blocks. This analytic approach allowed us to answer whether cognitive functioning and family risk factors share explanatory variance or whether they contribute with independent explained variance to ADHD and ODD behaviors, respectively.

To address the specificity in associations between cognitive functioning and family risk factors in relation to ADHD and ODD behaviors, each regression model was reanalyzed with ODD behaviors as a covariate for IA and H/I behaviors and IA and H/I behaviors as covariates for ODD behaviors.

## Results

Table 1 presents descriptive data for all measures. There were no significant gender differences or significant correlations between age and any of the measures. No bivariate or multivariate outliers were found based on the criterion of Cook's $D > 1$.

Intercorrelations among all variables are shown in Table 2. We found performance on WM and interference control to be negatively correlated with IA behaviors only, whereas slower MRT and higher RT variability were associated with high levels of both ADHD and ODD behaviors. For ADHD behaviors, among the family risk factors, parents' educational level was negatively correlated with both behavioral scales and the life event scale was positively correlated with IA behaviors. Higher levels of ODD behaviors, however, were associated with all family risk factors, that is, to more chaos in the home environment, more life events, a lower level of parental education, and a higher score on the adversity index. Inhibition (commission errors on the go/no-go task) was not found to be significantly correlated with any of the behavioral scales and was therefore excluded from subsequent analyses.

For the two behavioral scales of ADHD, cognitive functioning as a block contributed significantly both when

**Table 3.** Hierarchical Regression Models Evaluating Separate and Independent Contributions to ADHD and ODD Symptom Behaviors ($N = 100$)

| | Inattention | | Hyperactivity/ impulsivity | | ODD | |
|---|---|---|---|---|---|---|
| Predictor | $\Delta R^2$ | β | $\Delta R^2$ | β | $\Delta R^2$ | β |
| Step 1: Cognitive functions | .17**,a | | .13*,a | | .10* | |
| Working memory | | −.12 | | .01 | | .06 |
| Interference control | | .08 | | −.03 | | −.04 |
| Mean reaction time | | −.12 | | −.14 | | .02 |
| Reaction time variability | | .40**,a | | .43**,a | | .32*,a |
| Step 2: Family factors | .06 | | .03 | | .16**,a | |
| Parent's education | | −.08 | | −.12 | | −.09 |
| chaos | | .11 | | .04 | | .20 |
| Life events | | .20 | | .11 | | .28*,a |
| Adversity index | | −.09 | | −.18 | | −.02 |
| Step 1: Family factors | .08 | | .05 | | .20***,a | |
| Parent's education | | −.17 | | −.18 | | −.15 |
| Chaos | | .11 | | .08 | | .21*,a |
| Life events | | .15 | | .09 | | .25*,a |
| Adversity index | | −.04 | | −.11 | | .02 |
| Step 2: Cognitive functions | .15**,a | | .11*,a | | .06 | |
| Working memory | | −.18 | | .00 | | −.05 |
| Interference control | | .07 | | −.05 | | −.06 |
| Mean reaction time | | −.12 | | −.16 | | .02 |
| Reaction time variability | | .36**,a | | .43**,a | | .23 |

Note: ODD = oppositional defiant disorder.
[a]Denotes effects that were significant ($p$ >.05) when controlling for nonverbal intelligence.
*$p < .05$. **$p < .01$. ***$p < .00$.

entered in the first and second step (after the family risk factors) of the regression analyses (see Table 3). Controlling for IQ did not have an effect on the contribution of cognitive functioning for IA or H/I. The block of family risk factors was not significantly associated with any of the ADHD behavior scales, neither when entered in Blocks 1 or 2. After controlling for ODD behaviors, cognitive functioning, as a block, still contributed to IA symptoms ($\Delta R^2 = .08$, $p < .05$; βs ranging between .11 and .21). For the H/I behavior scale, after controlling for ODD behaviors, the contribution by cognitive functioning as a block ceased to be significant ($\Delta R^2 = .04$, *ns*, βs ranging between .03 and .25), although the measure of RT variability was still significantly associated with H/I behaviors.

For ODD behaviors, we found contributions of cognitive functioning and family risk factors through significant associations in the first step of the regression analysis, consistent with the correlational results, but only the latter contributed independently, that is when entered in the second step. Neither controlling for IA behaviors and H/I behaviors nor IQ substantially affected the associations between family risk factors and ODD in the first step ($\Delta R^2 = .08$, $p < 0.01$; βs ranging between −.05 and .16) or second step ($\Delta R^2 = .07$, $p < 0.01$; βs ranging between −.05 and .17), but the association between ODD behaviors and cognitive functioning shown in the first step ceased to be significant ($\Delta R^2 = .02$, *ns*; βs ranging between −.03 and .10).

Regarding contributions of specific measures within the blocks, it should be noted that, among the cognitive functions, only RT variability contributed independently of the other cognitive functions to ADHD behaviors, whereas among the family risk factors, only life events and chaos contributed independently of the other family risk factors to ODD behaviors.

## Discussion

We investigated the extent to which ADHD and ODD behaviors in adolescents show unique associations to cognitive functioning and/or family risk factors. This issue was addressed in two ways. First, we examined if cognitive functioning and family risk factors were independently associated with ADHD and ODD behaviors, respectively. Second, we examined the specificity in associations between cognitive functioning and family risk factors and type of problem behavior by controlling for ADHD behaviors when studying ODD behaviors and vice versa. The main findings were as follows: (a) Only cognitive functioning was associated with ADHD behaviors; (b) family risk factors were, independently of cognitive functioning, associated with ODD behaviors; and (c) with regard to specificity, ADHD behaviors were associated with cognitive functioning and ODD behaviors with family risk factors. These findings imply that the co-occurrence between ADHD and ODD behaviors are not readily explained by the presence of shared associations with poor cognitive functioning and/or family risk factors.

## *Contributions of Cognitive Functioning and Family Risk Factors*

To our knowledge, this is the first study that investigates independent associations of cognitive functioning and family risk factors to both ADHD and ODD behavior in adolescence. Our data suggest that only cognitive functioning is associated with IA and H/I behaviors. However, some of the family risk factors had significant bivariate correlations with ADHD behaviors. Therefore, it is possible that effects of family risk factors would have been found in a larger sample. In fact, a study by Forssman et al. (2009) found family risk factors, with similar effect sizes, to be associated with ADHD behaviors beyond cognitive functioning in large samples of both children and adolescents. For ODD behaviors, we found an association with cognitive functioning, but only when family risk factors were not taken into account. This suggests that there is an overlap between cognitive functioning and family risk factors in relation to ODD behaviors, with the latter being uniquely relevant for this type of problem behavior. However, it is worth noting that poor cognitive functioning could be seen as a manifestation of IA and/or H/I behaviors rather than a risk factor of ADHD, although it seems more plausible that family risk factors precede ODD behaviors.

## *Specificity of Cognitive Functioning in Relation to ADHD and ODD Symptoms*

As expected, ADHD behaviors, but not ODD behaviors, were primarily related to cognitive functioning after controlling dimensionally for each problem behavior. This shows that poorer cognitive functioning is a specific problem associated with ADHD behaviors and not ODD behaviors, which could reflect a stronger genetic transmission of ADHD behaviors than ODD behaviors. This result is in line with previous studies on ADHD and ODD in children that also controlled dimensionally for each symptom scale and found associations between EF and ADHD only (Brocki et al., 2007; Oosterlaan et al., 2005; Thorell & Wåhlstedt, 2006). Our results also highlight the importance of such dimensional control analyses. More precisely, in doing so, we illustrated that the alleged association between ODD behaviors and cognitive functioning can in part be explained by the co-occurrence between ODD and ADHD behaviors. We have furthered previous results by investigating the issue of cognitive functioning in relation to both ODD and ADHD behaviors and by including measures of response speed and variability as aspects of more broadly defined cognitive functioning.

In line with previous research (see Chhabildas et al., 2001; Lui & Tannock, 2007), problems with cognitive functioning were found to be more relevant for IA than H/I behaviors. In the correlation analysis, IA symptom behaviors were related to all cognitive functions, whereas H/I behaviors were related only to RT speed and variability, as were ODD behaviors. The robust association between the broad category of cognitive functioning and IA behaviors remained even after controlling for ODD; in contrast, the relations between H/I behaviors and cognitive functioning were reduced to nonsignificance when controlling for ODD. In relation to the co-occurrence of ADHD and ODD behaviors, this might mean that there is a specific overlap between H/I behaviors and ODD behaviors in terms of cognitive functioning; in our data, this was reflected in high RT variability in that this was the only measure that was significantly associated with H/I behaviors previous to the control for ODD behaviors. The fact that among the cognitive measures only RT variability contributed independently of the other cognitive measures to ADHD and ODD behaviors deserves some elaboration.

This association between RT variability and ADHD is one of the most robust findings in the ADHD literature (Castellanos et al., 2005; Kuntsi et al., 2001). Different theories exist in terms of how to interpret the significance of RT variability. Sergeant (2000) has proposed that it represents a deficiency in the regulation of arousal and activation (state regulation) that can be understood as a bottom-up process, necessary for efficient performance on EF tasks. Others have suggested that it represents impairment in temporal processing, the functioning of which is dependent on both control of motor processes and WM, and which when lacking leads to a high frequency of both slow and fast responses (Castellanos & Tannock, 2002). Our data, showing an independent contribution of RT variability, further underlines the importance of examining RT variability more closely and the need for advancing theories of its role in relation to ADHD behaviors.

## *Specificity of Family Risk Factors in Relation to ADHD and ODD Behaviors*

The findings showed that family risk factors are specifically related to ODD behaviors. This is consistent with studies that have shown that individuals with ODD, but not ADHD, come from families with more problems in the home environment in preschool (Cunningham & Boyle, 2002) and adolescence (Rey et al., 2000). It is possible that psychosocial adversity is more characteristic for those with severe ADHD. This may account for the difference in results between ours and Counts et al.'s (2005) study who reported that ADHD was associated with family adversity independently of ODD. Support for this interpretation comes from research by Scahill and coworkers (1999) on ADHD and subthreshold ADHD, where only the former had strong associations with psychosocial adversity. Therefore, associations between family risk factors and ADHD symptoms may primarily be found in clinical groups although this needs to be investigated further.

Among the family risk factors, stressful life events and chaos in the home environment seem to be of specific importance as they contributed independently of the other family risk factors to ODD behaviors. It is possible that both these factors can be characterized as stressors that assist in maintaining and/or increasing symptom levels in adolescents who already experience behavioral problems (Burke et al., 2002; Mathijssen et al., 1999).

## Limitations

As the current study is cross-sectional, it only provides information about a particular point in time. Furthermore, the sample's limited range of expressed problem behaviors may put constraints on the generalizability of the results to clinical populations. Obviously, research on community-based longitudinal studies is needed that describe the association between cognitive and family risk factors to participants with clinical levels of ADHD and ODD over time. Still, our study points toward the importance of controlling dimensionally for ODD when studying ADHD and vice versa to fully understand their associations with cognitive functioning and family risk factors and that is an approach that would also be beneficial for clinical studies. Another important task for future studies is to include a broader battery of cognitive measures and examine more closely whether other cognitive functions may be particularly related to ODD behaviors. For instance, some authors have suggested that affectively laden aspects of cognitive functioning may be of particular importance for ODD (e.g., van Goozen et al., 2004).

## Conclusion

In summary, our work reveals that poor cognitive functioning has specific significance for ADHD behaviors, whereas family risk factors have specific importance for ODD behaviors in adolescence. These results imply that the high co-occurrence between ADHD and ODD behaviors cannot be explained by the presence of shared risk factors. Thus, the explanations to the co-occurrence should be sought elsewhere, including shared genetic heritability. However, the great overlap between ADHD and ODD behaviors suggest that individuals with these symptoms will be better helped with an intervention geared at several aspects of functioning.

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