Executive functioning in children: a comparison of hospitalised ODD and ODD/ADHD children and normal controls

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Background: Deficits in executive functioning are supposed to have a predisposing influence on impulsive or aggressive behaviour. We tested the hypothesis that oppositional-defiant disorder (ODD) children with or without attention deficit hyperactivity disorder (ADHD) have problems in executive functioning.

Method: Seventy-seven 7- to 12-year-old children (15 ODD, 26 ODD/ADHD, and 36 normal controls), all with normal IQ, completed 7 neuropsychological measures of executive functioning, assessing the abilities of set shifting, planning, working memory, inhibition/attention, and impulsivity. Some of these tasks involved the possibility of monetary rewards with a view to testing the prediction of a specific motivational inhibitory deficit.

Results: We found no evidence of deficits in working memory, planning, inhibition, or impulsivity. However, the ODD/ADHD group was worse than the normal control (NC) group in set shifting, and both the ODD and ODD/ADHD groups performed worse on a response perseveration task. Moreover, on the basis of one variable derived from a motivational inhibition task, 77% of the children could be correctly classified as ODD or NC.

Conclusions: The findings do not support the hypothesis that ODD and ODD/ADHD children have a deficit in executive inhibitory control; rather, they emphasise that they have problems in regulating their behaviour under motivational inhibitory conditions.

Keywords: Executive functioning, ODD, ADHD, inhibition, reward and punishment sensitivity.

Abbreviations: ADHD: attention deficit hyperactivity disorder; BAS: Behavioural Activating System; BIS: Behavioural Inhibition System; CD: conduct disorder; EF: executive function; NC: normal control; ODD: oppositional-defiant disorder.

Children with an oppositional-defiant disorder (ODD) or a conduct disorder (CD; DSM-IV; APA, 1994) show persistent disruptive behaviour that affects diverse domains of their functioning. The prognosis for CD/ODD children is unfavourable: they are at a high risk for delinquency, social isolation, addiction and other psychiatric disorders in adolescence and adulthood (percentages ranging between 50% and 60% have been reported). This is why child-onset disruptive behaviour is a major predictor of chronic and increasingly violent forms of antisocial behaviour (Loeber & Stouthamer-Loeber, 1997). Part of the reason for the persistence of this type of problem behaviour is that we lack a good understanding of the cognitive-emotional problems of these children and their neuropsychological and neurobiological characteristics, with the result that optimal interventions have not yet been developed.

It is believed that executive dysfunction has a predisposing influence on impulsive and aggressive behaviour (Pennington & Bennett, 1993; but see also Moffitt, 1993a). The aim of the present study is to examine whether children with serious disruptive behavioural disorder show evidence of executive dysfunction. We will investigate whether executive dysfunctions are generally present in children with ODD or are present only in those ODD cases with an ADHD comorbidity. Finally, we will explore whether ODD children suffer from problems in executive inhibitory control or have a more specific problem in motivational inhibitory control.

In reviewing research using neuropsychological executive function (EF) measures it is apparent that when neuropsychological deficits are observed they are often attributable to individuals or subgroups with ADHD or an ADHD comorbidity (Moffitt & Henry, 1989; Rubia et al., 2001). Thus, hyperactive children in general perform poorly on a variety of executive function measures, and working memory is predicted to be particularly important (Pennington & Ozonoff, 1996; but see also Kuntsi, Oosterlaan, & Stevenson, 2001). However, within the domain of ADHD different theories with respect to the precise nature and extent of the cognitive deficits exist. Barkley (1997) proposed that a deficit in behavioural inhibition, as the primary executive self-regulatory act necessary for performing other executive functions, is the core deficit of ADHD. Poor inhibitory performance has been shown in some studies to be specifically related to ADHD and not to CD (Schachar & Tannock, 1995). However, Sonuga-Barke and colleagues (e.g., Sonuga-Barke, Williams, Hall, & Saxton, 1996; Sonuga-Barke, Saxton, & Hall, 1998)
claim that the fact that hyperactive children tend to respond prematurely on tasks in which they are instructed to withhold responding for a pre-determined period, and prefer small immediate rewards over larger delayed rewards, does not mean that they have an inhibitory dysfunction (see Tripp & Alsop, 2001). In a series of studies they showed that this pattern of responding is consistent with the hypothesis that these children are delay averse, which implies that their problem is more motivational in nature. In a recent study Kuntsi et al. (2001) tested these three different theories of hyperactivity (working memory impairment, delay aversion, and response inhibition deficit) in a group of hyperactive and control children and found that the predicted group differences emerged most clearly on the delay aversion measure.

The evidence for EF deficits in CD or ODD is not very strong and it therefore remains unclear whether EF deficits are specifically related to ADHD or are also evident in children with ODD and comorbid ODD plus ADHD (Hill, 2002). Although ODD is considered to be a milder and earlier variant of CD, inhibition problems are part of the diagnostic criteria of ODD whereas they are not in the case of CD. For example, the defining characteristics in the diagnosis of ODD are that a child loses her/his temper quickly and that s/he is touchy and easily annoyed by others. These aspects of the problem behaviour are clearly reflective of disinhibition and impulsivity. Moreover, if EF deficits exist at all in ODD one would predict stronger supportive evidence in young ODD children because the more persistent childhood-onset form of ODD, which is distinguished from the adolescent-onset form (Moffitt, 1993b), is assumed to have a higher neurobiological risk factor. Research focusing on specific EF measures administered to ODD children who are hospitalised because of the severity of their behavioural problems, including children with a comorbid diagnosis of ADHD, may be more successful in detecting specific EF deficits.

Research on inhibition and its relation to disruptive behaviour disorders distinguishes between executive inhibitory control, which is the suppression of behaviour or thought in the service of a later goal, and motivational inhibitory control, defined as the suppression of behaviour in response to immediate incentives, fear and anxiety (Nigg, 2000). Kindlon, Mezzakappa, and Earls (1995) used a large battery of neuropsychological tests of executive frontal lobe function and found evidence in support of this distinction between cognitive and motivational impulsivity. However, they also found that normal children and behaviourally disordered children differed on nearly all the tests used. Although their disturbed group was recruited from therapeutic elementary schools, it is not clear how seriously disturbed the children were, whether the groups differed with respect to IQ, or whether they fitted specific psychiatric diagnoses. Furthermore, the authors did not specifically test whether the disturbed children suffered more from problems in executive or motivational inhibition.

A relevant neuropsychological theory is the BIS/BAS theory of Gray (1994). Briefly stated, the Behavioural Inhibition System (BIS) is regulated by the septohippocampal and prefrontal systems in the brain and inhibits behaviour in response to cues of punishment or non-reward. People with an overactive BIS are inhibited and anxiety-prone; those with an underactive BIS are punishment-insensitive. The Behavioural Activating System (BAS) is mediated neurally by ascending dopaminergic fibres in the reward or appetitive system of the brain and is activated by cues of reward or non-punishment and therefore results in approach or active avoidance behaviour. People with an overactive BAS are impulsive. It is clear that a balance in BIS and BAS functioning is necessary for optimal functioning.

Several studies have been conducted to establish whether the behavioural problems of CD children can be understood as being driven by reward or by insensitivity to punishment. Such studies have used reward-alone conditions, punishment-alone conditions, and combined reward-plus-punishment conditions (Newman, Widom, & Nathan, 1985; Newman & Kosson, 1986). The evidence shows that in a combined condition including both rewards and punishments CD children perform poorly on tasks measuring motivational inhibition because they focus on reward at the expense of punishment (Daugherty & Quay, 1991); ADHD children apparently do not differ from normal controls in combined conditions. There is, however, strong evidence that ADHD children perform worse on a stop signal task, suggesting an under-responsive inhibition system; CD children perform similarly to the controls on this task and it can therefore be concluded that their BIS is quite functional given the appropriate circumstances (e.g., cues of punishment; see Schachar & Logan, 1990). Finally, the relatively greater impairment in functioning of children comorbid with ADHD and CD symptoms, as opposed to either disorder on its own, may be due to a dominance of BIS over BAS (in CD) combined with a dysfunctional BIS (in ADHD). In one study (Matthys, van Goozen, De Vries, Cohen-Kettenis, & Van Engeland, 1998) we found that participants with a CD or CD/ADHD pattern of behaviour perseverated in responding on the reward/punishment task we used in the present study, and that boys comorbid with CD and ADHD performed significantly worse than boys with CD alone, supporting the idea that the functioning of CD/ADHD children is more impaired than that of CD children.

In the present study we compared the performance of early-onset clinical ODD children, children comorbid with ODD and ADHD, and normal controls on a variety of executive function (EF) measures in order to examine whether specific EF deficits are
present in ODD and ODD/ADHD children with normal IQ, or only in ODD children with an ADHD comorbidity. Our selection of specific EF abilities and their operationalisations were based primarily on the overview study of Pennington and Ozonoff (1996), but also on work by Moffitt and Henry (1989). For exploratory purposes we added two tests with a reward and punishment sensitivity component (Krueger, Caspi, Moffitt, White, & Stouthamer-Loeber, 1996; Matthys et al., 1998) in order to investigate whether any existing inhibitory deficit in ODD was more motivational than executive in nature. It was predicted that the addition of a reward and punishment component would increase the demand for motivational inhibitory control. Specifically, we expected the BIS in ODD and ODD/ADHD children to be malfunctioning once the BAS system had been activated, and that these children would therefore ignore signals of punishment as losses accrued. We also explored whether the relatively greater impairment in functioning of children comorbid with ADHD and CD symptoms as opposed to children with ODD alone could be due to a dominance of BAS over BIS (in CD) combined with a dysfunctional BIS (in ADHD). If true, this should then be reflected in the results on the motivational inhibition tasks.

Materials and methods

Participants

Participants (n = 77) were aged between 7 and 12 years (mean age ODD group = 10.1 (sd = 1.2) years; mean age ODD/ADHD group = 9.5 (sd = 1.6) years; mean age NC group = 9.2 (sd = 1.2) years; F (2, 74) = 2.40, p > .05). The normal control children (NC; n = 36, 14 boys and 22 girls) were recruited from grades 3, 4, 5 and 6 of a regular elementary school. The ODD group (n = 41) consisted of boys (n = 36) and girls (n = 5) who met the criteria for oppositional-defiant disorder or conduct disorder as specified in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; APA, 1994). The clinical group was solicited from a specialised clinic for the treatment of ODD of the Department of Child and Adolescent Psychiatry, University Medical Centre Utrecht. Diagnoses of the ODD patients were based on extensive psychiatric assessment of the child and interviews with the parents. Moreover, the presence or absence of psychopathology of all children was determined using a standard parent interview (DISC-P; Schaffer, 1992). Within the NC group one boy had ADHD as assessed by the DISC-P: within the ODD subgroup (n = 15) children had the following comorbid diagnoses as assessed by the DISC-P: CD (n = 3), depression (n = 3) and anxiety disorder (n = 5); within the ODD/ADHD subgroup (n = 26) children had the following comorbidities: CD (n = 7), depression (n = 5), anxiety disorder (n = 9), obsessive compulsive disorder (n = 1), Tourette/tic disorder (n = 3), enuresis/encopresis (n = 3).

The Child Behavioural Checklist (CBCL; Achenbach, 1991a) was completed by each participant’s primary caretaker. The children’s teachers completed the teacher version (TRF) of the CBCL (Achenbach, 1991b). The T-scores of Anxious/Depressed, Attention Problems, Externalising Problems (aggression and delinquency), and Internalising Problems (withdrawn, somatic complaints, anxious depressed) are presented in Table 1. ODD and ODD/ADHD children differed significantly (p < .01) from controls on all CBCL and TRF subscales; ODD children differed from ODD/ADHD children on CBCL Attention problems and Delinquency, and TRF Delinquency (see Table 1).

| Table 1 Scores on the WISC-R and CBCL and TRF in ODD, ODD/ADHD and NC children |
|-------------------------------|------------------|------------------|------------------|------------------|------------------|
|     | ODD       | ODD/ADHD |       | NC           |
|     | Mean  | SD | Mean  | SD | Mean  | SD | F    | Bonferroni |
| Vocabulary | 9.1 | 3.5 | 8.4 | 2.3 | 9.3 | 2.1 | 1.1 |           |
| Block design | 10.8 | 3.5 | 9.7 | 3.4 | 9.8 | 1.8 | .9 |           |
| Estimated IQ | 99.4 | 17.4 | 94.4 | 10.6 | 97.4 | 8.8 | 14.8** | od>nc & od/ad>nc |
| CBCL- anxious | 64.3 | 10.8 | 64.8 | 11.2 | 53.5 | 5.8 | 31.4** | od>nc & od/ad>nc & od/ad>od |
| CBCL-attention | 60.1 | 8.5 | 69.9 | 9.3 | 53.7 | 6.4 | 43.6** | od>nc & od/ad>nc & od/ad>od |
| CBCL-delinquency | 60.0 | 9.1 | 67.8 | 7.5 | 51.8 | 4.4 | 28.4** | od>nc & od/ad>nc |
| CBCL-aggress | 62.1 | 10.9 | 69.0 | 12.0 | 51.9 | 4.1 | 48.4** | od>nc & od/ad>nc |
| CBCL-extinction | 61.3 | 9.5 | 68.1 | 9.7 | 45.0 | 9.0 | 30.4** | od>nc & od/ad>nc |
| CBCL-inhibition | 65.7 | 8.4 | 65.2 | 10.0 | 47.6 | 10.5 | 53.7** | od>nc & od/ad>nc |
| CBCL-total | 64.2 | 7.7 | 68.8 | 7.8 | 55.3 | 10.7 | 89.0** | od>nc & od/ad>nc |
| TRF-anxious | 66.8 | 5.5 | 67.8 | 8.0 | 50.7 | 2.8 | 33.6** | od>nc & od/ad>nc |
| TRF-attention | 61.0 | 6.9 | 59.9 | 7.1 | 50.6 | 1.4 | 78.9** | od>nc & od/ad>nc & od/ad>od |
| TRF-delinquency | 62.1 | 5.5 | 68.1 | 7.5 | 51.0 | 2.8 | 47.2** | od>nc & od/ad>nc |
| TRF-aggress | 65.6 | 8.0 | 73.7 | 13.0 | 52.2 | 3.7 | 71.0** | od>nc & od/ad>nc |
| TRF-ext | 65.3 | 6.5 | 71.7 | 10.3 | 47.1 | 6.7 | 113.7** | od>nc & od/ad>nc |
| TRF-int | 67.4 | 7.0 | 67.3 | 7.9 | 42.6 | 6.1 | 114.9** | od>nc & od/ad>nc |
| TRF-tot | 66.8 | 6.4 | 69.6 | 7.8 | 42.6 | 7.1 | 114.9** | od>nc & od/ad>nc |

ODD = Oppositional Defiant Disorder; ADHD = Attention Deficit Hyperactivity Disorder; NC = normal controls; CBCL = Child Behavior Check List; anxious = anxious/depressed (CBCL T); attention = attention problems (CBCL T); delinquency = delinquent behavior (CBCL T); agress = aggressive behavior (CBCL T); ext = externising (CBCL T); int = internalising (CBCL T); tot = total score (CBCL T); TRF = Teacher Report Form.

* = p < .05; ** = p < .01.
The patients were administered the complete Wechsler Intelligence Scale for Children (WISC-R; Wechsler, 1974). For the normal controls two subtests (Vocabulary and Block Design) of the WISC-R (van Haasen et al., 1986) were used, which correlate .90 with full-scale IQ (Sattler, 1992). Estimated full-scale IQ scores and standard scores on the subtests are also shown in Table 1. There were no differences between the groups in Vocabulary and Block Design scores, or in their estimated IQ scores (WISC-R; see Table 1). The clinical children were administered the complete WISC-R on a separate occasion (Wechsler, 1974). Their mean VIQ score was $M_{	ext{VIQ}} = 93.1$ (sd = 16.7) and $M_{	ext{VIQ/adhd}} = 93.4$ (sd = 10.3), mean PIQ score was $M_{	ext{PIQ}} = 103.3$ (sd = 18.4) and $M_{	ext{PIQ/adhd}} = 100.4$ (sd = 12.7), and mean IQ score was $M_{	ext{IQ}} = 97.7$ (sd = 17.9) and $M_{	ext{IQ/adhd}} = 96.2$ (sd = 10.7). Within the clinical group there was a correlation of .78 between the estimated and full-scale TIQ.

### Measures

**Set shifting.** The Trail-Making Test, Forms A and B (Trails), was used to assess set shifting (Reitan & Davison, 1974). Trails B has been found to be sensitive to frontal-lobe brain damage (Boll, 1981). This task measures the ability to initiate, switch, and stop a sequence of complex purposeful behaviour, and attention and concentration skills. The child must first draw lines to connect 15 consecutively numbered circles in ascending order as fast as possible (Trails A) and then connect consecutively numbered and lettered circles (i.e., 1, A, 2, B, ... 7, G, 8) on a second worksheet (Trails B) by alternating between the two sequences. Three measures were taken: time required to complete Trails A (Trail A time), time required to complete Trails B (‘Trail B time’), and the time required to complete Trails B minus the time required to complete Trails A (Trail (B–A) time) (Moffitt & Henry, 1989).

**Working memory.** Working memory is considered to be an ability that the so-called executive function measures share. Working memory was assessed using the Self-Ordered Pointing (SOP) task (Petrides & Milner, 1982). The goal of the task is to point to a picture one has not pointed to before, with the pictures appearing in random order. The SOP task consists of 5, 6, 7, 8 and 10 concrete and abstract pictures and was implemented on an Apple Macintosh computer, with the arrangement of concrete pictures and abstract forms changing in location on consecutive screens (Wiers, Gunning, & Sergeant, 1998). Both the concrete and abstract form versions were used because they differ in difficulty. Our sample contained children of a relatively wide age range (7 to 12 years) and negative results with young children have been reported (Shue & Douglas, 1992). Two scores were calculated: the number of errors on the concrete pictures (‘SOP-concrete’) and the number of errors on the abstract forms (‘SOP-abstract’).

**Planning.** Planning was assessed with the Tower of Hanoi (TOH; Welsh, Pennington, Ozonoff, Rouse, & McCabe, 1990). The TOH puzzle consisted of three vertical posts and three doughnut-like discs of different colour and size, which fitted on the pegs. The participant was shown the model array and asked to duplicate the arrangement on a second apparatus in the minimum number of moves, while obeying the following rules: (1) only one disc may be moved at a time; (2) a larger disc must not be placed on top of a smaller disc; (3) discs may not be placed on the table (see also Bishop, Aamodt-Heep, Creswell, McGurk, & Skuse, 2001). Although different scores have been used to assess planning ability (e.g., number of items solved in the minimum number of moves possible, number of trials needed to solve an item, latency of the first move, highest level of task successfully completed, etc.) we used as final score the number of attempts needed to complete the task in 7 or fewer steps (‘TOH steps’). The maximum number of attempts allowed was 6. Although the validity and reliability of the TOH have recently been questioned as a clinical index of EF, Bishop et al. (2001) concluded that the test is adequate for demonstrating group differences between clinical and control groups.

**Inhibition and attention.** Two tests were used. The Stroop Color-Word Test (SCWT; Stroop, 1935) measures interference control and requires inhibition of an over-learned automatic response. The test consists of three conditions: (1) words – the word ‘red’, ‘green’, ‘yellow’, or ‘blue’ written in a neutral colour; (2) colours – patches of red, green, yellow or blue, and (3) colour-word – the words ‘red’, ‘green’, ‘yellow’, or blue written in conflicting colours. In each of the three conditions the participant has to make the correct identification as quickly as possible. The time required to complete each stimulus set is recorded. In the colour-word or ‘interference’ condition the participant has to name the colour, not the word. This requires both selective attention to the primary, or colour stimulus, and inhibition of the dominant tendency to name the ‘distractor’, or word stimulus (Kindlon et al., 1995). The dependent variable used (‘SCWT-inttime’) is the time required to complete the stimulus set in the interference condition.

The Continuous Performance Test, version AX (CPT-AX; Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956) was used to assess difficulty in sustained attention, which is known to be a significant disability in children with ADHD (Halperin, Matier, Bedi, Vandehey, & Newcorn, 1992; Pennington & Ozonoff, 1996). In the CPT participants are asked to detect a target event among a sequence of briefly presented stimuli and to avoid responding to distractor stimuli (Cohen & Servan-Schreiber, 1992). In the computerised CPT-AX used in the present study the target event is the appearance of a stimulus in a particular context (e.g., ‘Push the “yes” button when a square follows a circle’). The task consisted of a series of 300 stimuli, each of which was presented for 600 msec, with an interstimulus interval of 900 msec. Mean task duration was about 10 minutes. Performance was measured by the number of correct responses or hits (‘CPT-correct’); maximum hit score was 30) and the number and type of erroneous responses. Two types of errors were distinguished. Generally, omission errors (‘CPT-omis’) reflect missed targets and are therefore assumed to reflect deficits in sustained attention or vigilance; commission errors or false alarms (‘CPT-commis’) reflect rapid responses without taking sufficient time to evaluate the information and are therefore assumed to indicate
impulsiveness. Speed of performance is another relevant factor. Performance during time on task seems to be especially relevant in evaluating the stability of attentional control. Fluctuation in the speed of stimulus evaluation was indicated by the variability of the mean reaction time after hits (CPT-sdtime).

Perseveration of responses. The Door Opening Task (DOT; Daugherty & Quay, 1991; Matthys et al., 1998) was played on a computer. This is a simplified version of the card-playing task (Newman, Patterson, & Kosson, 1987). In this task, which consists of 110 trials, money is either won or lost, but there is a steady decrease in the probability of winning 10 cents (from 100 to 0%) and the participant has to decide how long to continue playing. Stopping too quickly results in winning less money than is theoretically possible, but the same applies to playing too long. The latter behaviour has been defined as perseveration in the context of changing response contingencies (Newman & Wallace, 1993). The following dependent measures were used: first, the number of doors opened (DOT-perseveration); second, the number of premature responses as an index of impulsivity (DOT-premature), defined as the number of trials on which the participant tapped on the button to open the next door before this door actually had appeared on the computer screen; third, the elapsed time between losing 10 cents and pushing on the next button (DOT-time lose), which was considered to be a BIS measure and reflect sensitivity to punishment; and fourth, the elapse in time between winning 10 cents and pushing on the next button (DOT-time win), which was considered a BAS measure and to reflect sensitivity to reward.

Delay aversion. Another aspect of motivational inhibition is the tendency to choose immediate over delayed reward. According to Sonuga-Barke and colleagues (1996, 1998), children with hyperactivity disorder are not impulsive in the sense that they are unable to wait but they prefer not to wait. Thus their inhibitory deficits could be due to an aversion to delay. We used a computerised Delay of Gratification Task (DGT) similar to the one described by Krueger et al. (1996). The child is presented with 40 trials. Each involves a choice between an immediate response with a less desirable outcome (button 1 with a 40% probability of winning a nickel), and a delayed response (12 seconds) with a more desirable outcome (button 2 with a 80% probability of winning a nickel). The participant plays 10 ‘button 1’ and 10 ‘button 2’ practice trials in order to ensure that he or she understands the workings of the task. The two primary variables are the number of nondelayed/immediate (DGT-nondelay) and delayed responses (DGT-delay).

Data analysis

One-factor analyses of variance (ANOVA) were used to assess the effect of diagnostic group (ODD, ODD/ADHD, NC) on WISC-R subtests, ratings of anxiousness, attention problems, delinquency and aggression (CBCL, TRF), and various EF tests. In the event of significant group differences post hoc Bonferroni tests were done. Stepwise discriminant and logistic regression analyses were performed to investigate the contribution of the different neuropsychological variables to the differences between the groups.

Results

Because the normal control (NC) group consisted of more girls than boys (22 girls, 14 boys), a sex ratio that was different for the ODD group (5 girls, 36 boys), we first established whether sex was a factor that needed to be taken into account. To this end we tested whether there were significant gender differences within the NC group on the various neuropsychological variables. Girls were found to be slower on Trails A (mean girls = 46.8 (12.9), mean boys = 34.1 (8.8); F (1, 34) = 10.4, p < .01) and Trails B (mean girls = 110.9 (34.3), mean boys = 88.8 (17.5); F (1, 33) = 4.93, p < .05), but there was no difference in the combination score (Trail B-A). Furthermore, girls did worse on the abstract version of the SOP task, measuring working memory (mean girls = 6.8 (2.9), mean boys = 4.6 (2.0); F (1, 34) = 5.66, p < .05).

When we excluded all girls from the sample and analysed for group differences on the executive functioning variables included in the present study, the same significant differences between groups were found as when the girls were included, the only exception being that we also found a group difference on the Stroop test, with ODD/ADHD boys doing worse than normal controls. Taking into account the number of variables measured and the fact that gender differences were found only for a few subtest variables and not for any of the separate EF abilities, we concluded that gender did not play an important role in moderating performance.

One-way analyses of variance (ANOVA) were carried out to establish whether ODD children in general performed worse on different EF measures (hypothesis a) or whether these were only found in children with an ADHD comorbidity (hypothesis b). No significant effects were present with regard to five EF measures: working memory (SOP), planning (TOH), inhibition/attention as measured by the Stroop test and by the CPT-AX, and impulsivity as measured by the delay of gratification test (DGT; see Table 2). ODD children with an ADHD comorbidity performed significantly worse on set shifting (Trail B, Trail (B-A)). The only task on which the two ODD groups performed significantly worse was the response perseveration task (DOT-perseveration). Moreover, ODD and ODD/ADHD children had a higher number of premature responses (DOT-premature) and faster reaction times after winners (DOT-time win) and losers (DOT-time lose). Post hoc tests with Bonferroni correction, however, revealed that only with respect to the reaction time after a winner (DOT-time win) was there a significant difference between the ODD/ADHD and NC groups (see Table 2).
It was not possible to create an aggregate score on the basis of the performances on the individual tasks. The reliability (Cronbach’s alpha) calculated over 11 key variables used in the study was too low, namely .42 (in the NC group separately the reliability was .29, in the clinical group it was .28).

Age was not responsible for any meaningful variation in performance on the various tests. The only ability for which the performance was significantly correlated with age was set shifting (Trail A: \( r = -.43 \), Trail B: \( r = -.33 \), Trail (B-A): \( r = -.23 \)). Age was a significant covariate in Trail B and Trail (B-A), but not in Trail A. In separate ANCOVA analyses controlling for the effect of age a significant main effect of group remained (Trail B: \( F (2, 69) = 5.90, p < .01 \); Trail (B-A): \( F (2, 69) = 6.72, p < .01 \)).

In order to investigate the contribution of each variable to the significant differences between the clinical children with ODD (combined ODD and ODD/ADHD), on the one hand, and the normal controls, on the other, a discriminant analysis using all neuropsychological test variables showed that 83% of the children could be correctly classified as ODD or NC. A stepwise discriminant analysis was carried out next, showing that the variable contributing most to this distinction was DOT-perseveration. On the basis of this variable alone 77% of the children could be correctly classified as ODD or NC. The next best discriminator was DOT-time win, our measure of BAS activation, which was able to classify 66% of the children correctly.

Next, a logistic regression analysis was conducted to establish which combination of tests discriminated between the ODD (only) and NC groups. Together all variables predicted 90% of the children correctly and on the basis of the DOT-perseveration variable alone 86% could be correctly classified.

Finally, a discriminant analysis was performed to examine the contribution of each variable to the significant differences between the ODD, ODD/ADHD, and NC groups. The variable contributing most to this distinction was again DOT-perseveration, followed by Trail B-A. On the basis of these two variables 65% of the children could be correctly classified as ODD, ODD/ADHD, or NC. Given the relative contributions of the different variables, the results of these analyses can be interpreted as indicating that clinical ODD children have a dysfunction in motivational inhibition, particularly under conditions of monetary reward.

Because anxiety plays an important moderating role in inhibition, we regressed all neuropsychological test scores on CBCL and TRF anxious/depressed scores. CBCL anxious/depressed was a significant predictor of DOT-time lose (beta = .44, \( p < .05 \)) and DOT time win (beta = .46, \( p < .05 \)). This reflects the fact that ODD children who were rated as more depressed/anxious by their caretakers had slightly longer inhibition times after losing or winning money. However, CBCL and TRF anxious/depressed scores were not significant predictors of any other neuropsychological variables.

In a parallel set of analyses we examined the role of anxiety based on the DISC-P outcomes and compared the performances of the ODD children with \( n = 14 \) and without \( n = 27 \) comorbid anxiety. These two ODD subgroups did not differ on any of the neuropsychological variables. Together, these results show that anxiety played a minimal role in shaping performance on these tests.

<table>
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<tr>
<th></th>
<th>ODD</th>
<th>ODD/ADHD</th>
<th>NC</th>
<th>( F )</th>
<th>Partial Eta Squared</th>
<th>Bonferroni</th>
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<tbody>
<tr>
<td>Trail A time</td>
<td>38.2 10.9</td>
<td>42.1 11.8</td>
<td>41.9 13.0</td>
<td>.58</td>
<td>.02</td>
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<tr>
<td>Trail B time</td>
<td>100.5 34.4</td>
<td>127.5 47.7</td>
<td>102.1 30.5</td>
<td>3.78*</td>
<td>.11</td>
<td>od/ad&gt;nc</td>
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<tr>
<td>Trail (B-A) time</td>
<td>62.4 28.9</td>
<td>86.0 41.5</td>
<td>60.4 24.2</td>
<td>4.99**</td>
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EF = Executive functioning; ODD = Oppositional-defiant disorder; ADHD = Attention deficit hyperactivity disorder; NC = normal controls. * = \( p < .05 \); ** = \( p < .01 \).
Discussion

The findings of this study do not support the idea that children with disruptive behaviour (ODD) have problems in executive functioning, or more specifically in executive inhibitory control. The only evidence of an executive deficit was found for ODD/ADHD children on a set-shifting task (the Trail-Making Test).

The results for the DOT and the delay of gratification (DGT) tasks, which measured motivational inhibition under conditions of reward and punishment, are especially interesting. On the DOT task both ODD groups performed significantly worse than did the NC group, showing that they continued to respond in the context of increasing losses. On the other hand, on the DGT task both ODD groups performed as well as the NC group, suggesting that they were able to withhold responding and were willing to do so when the increased waiting time increased the likelihood of winning money. On the basis of one variable from the DOT task alone, 77% of the children could be correctly classified as ODD (combined groups) or NC, and in similar two-way (ODD only and NC) and three-way (ODD, ODD/ADHD, NC) discriminations the same variable derived from this test was again the best predictor. In our view, the results indicate that children with ODD/CD do not have a dysfunction in executive functioning, but rather suffer from a specific dysfunction in inhibition, particularly under conditions of monetary reward. Their disorder therefore seems to be more motivational than executive in nature.

The data fit quite well with the previously discussed BIS/BAS theory (Gray, 1994). It is clear from the results on the Delay of Gratification task that ODD children can inhibit their impulsiveness under conditions in which greater reward is likely if they are able to delay their responding, and the same applies to children with an ADHD comorbidity. These results suggest that the reward sensitivity of ODD children enables them to delay and give up immediate gratification for the sake of later but greater reward. However, the results on the response perseveration task, measuring the modulation of BIS and BAS, indicate that they still have a problem in motivational inhibition: once their reward system is activated they are unable to respond to punishment signals. This conclusion is based not only on the number of trials played, but also on the significantly faster reaction times when winning and losing stimuli appeared on the computer screen. All in all, the results on both tasks and the fact that we did not find any substantial problems on other executive tasks, even among children with an ADHD comorbidity, indicate that ODD children's problem behaviour has more to do with motivational than executive inhibition, and is probably a combination of increased reward and decreased punishment sensitivity. Not only did their sensitivity to reward enable them to postpone impulsive behaviour that would have resulted in more immediate but less favourable consequences; they also ignored increasingly strong punishment signals once their reward sensitivity had been extensively reinforced. Importantly, there were no differences between ODD children with ADHD and those without it. Future studies, using conditions measuring punishment sensitivity in the absence of reward, and similarly, including conditions measuring reward sensitivity without the addition of a punishment component, are necessary to elucidate the nature of the motivational inhibitory deficit in ODD children.

Some limitations of the present study need to be noted. First, we did not include an ADHD group. Further studies using stringently defined subgroups, including groups with ADHD alone as well as an ADHD comorbidity, are necessary to investigate the diagnostic specificity of executive function impairments. Second, although the range of tasks we used was relatively large, the specific types of tasks used across the various studies on this topic differ, making between-study comparisons difficult. Moreover, in choosing particular tasks and ignoring others one might fail to capture all the ADHD and/or ODD deficits that one would ideally like to capture.

It is not clear why the ODD children with an ADHD comorbidity did not show the neuropsychological deficits that have been linked to ADHD (Pennington & Ozonoff, 1996), such as attention or executive inhibition deficits. Studies trying to delineate the unique characteristics of ADHD have shown that hyperactivity is such a symptom, but that inattention and impulsivity are not (e.g., Halperin et al., 1992). Discrepancies between clinical/behavioural definitions of ADHD and underlying (psychopharmacological deficits have also been observed (Overtoom et al., 1998). One possibility is that what is called a combination of ODD and ADHD in fact reflects a qualitatively different disorder, one that may have a different set of attentional or other cognitive deficits than children with ADHD alone. In this 'specific deficit' view a child with ODD/ADHD is not simply a child with a wider array of deficits or a more serious form of ODD (see also Scheres, Oosterlaan, & Sergeant, 2001). Future studies including children with ADHD, ODD, and ODD/ADHD, and focusing on a range of different measures (neuropsychological, neurobiological and (psychopharmacological) are needed in order to delineate more specifically the dysfunctions in these three subtypes of behavioural disorders. Sophisticated experimental designs will also be needed in order to distinguish between deficits in executive and motivational inhibition.

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References


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