Self-regulation in boys with oppositional defiant disorder and conduct disorder

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CHAPTER 5

Boys with oppositional defiant disorder/ conduct disorder show impaired adaptation during stress: An executive functioning study

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Abstract

Evidence for problems in executive functioning (EF) in children with oppositional defiant disorder/conduct disorder (ODD/CD) is mixed and the impact stress may have on EF is understudied. Working memory, sustained attention, inhibition and cognitive flexibility of boys with ODD/CD (*n*=65) and non-clinical controls (*n*=32) were examined under typical and stressful test conditions. Boys with ODD/CD showed impaired working memory under typical testing conditions, and impairments in working memory and sustained attention under stressful conditions. In contrast to controls, performance on sustained attention, cognitive flexibility and inhibition was less influenced by stress in boys with ODD/CD. These results suggest that boys with ODD/CD show impairments in adaptation to the environment whereas typically developing boys show adaptive changes in EF.

Introduction

Oppositional defiant disorder (ODD) and conduct disorder (CD) are developmental disorders (APA, 2013), affecting around three percent of children, with somewhat higher rates in boys (Matthys and Lochman, 2010). Children with ODD/CD are at risk for a variety of negative outcomes: school dropout, unemployment, criminality and other psychiatric disorders such as depression and anxiety (Bradshaw et al., 2010). In order to be able to positively influence development and optimize outcome, it is important to understand the mechanisms driving difficulties in behaviour adaptation, in terms of how information is processed and how behavioural responses are organized and controlled. Such knowledge may help in understanding why children with ODD/CD may show antisocial and aggressive behaviour, and thereby help in identifying targets for intervention.

Executive functioning (EF) is crucial for controlling cognitive processing, emotions and behaviour, and makes it possible to adapt behaviour in situations that are new, complex, unpredictable, or have high load of information (Anderson, 2002). These situations require EF to focus on what's necessary and regulate inappropriate behaviours. There are several key EF functions: working memory, attention, inhibition, cognitive flexibility, planning and monitoring (Anderson, 2002; Diamond, 2013). This study focused on the first four EFs. Working memory involves holding information in mind and is for example necessary for considering alternatives, making action plans and reasoning. Attention involves being able to focus on what was chosen and suppress interference of other stimuli. Inhibition, or self-control, ensures control over one's behaviour, actions and emotions. Cognitive flexibility means being able to adjust to changing demands or perspectives.

There is an increasing acknowledgement of the role emotions play in EF. This is particularly interesting because in everyday life emotional or motivational influences are rarely absent (Welsh and Peterson, 2014). Adequate functioning in emotionally charged or stressful situations requires flexibly adapting to changing environments, which may be compromised in children with ODD/CD, contributing to their antisocial and aggressive behaviour. The importance of the impact emotions have on EF is also illustrated by research distinguishing between EF in neutral situations and EF in the context of affect, incentives and motivation, i.e. 'cool' and 'hot' EF (Zelazo and Muller, 2002). Cool EF can turn into hot EF when a reward or punishment is introduced, thus when the situation becomes emotionally charged (Brock et al., 2009).

In ODD/CD samples EF deficits in typical test environments, i.e. cool EF, have been found, but to what extent they exist independently of ADHD comorbidity is controversial (Dolan and Lennox, 2013; Morgan and Lilienfeld, 2000; Pennington and Ozonoff, 1996). Additionally, studies that did find cool EF impairments reported various EF deficits: working memory, cognitive flexibility and planning impairments (Syngelaki et al., 2009) or sustained attention and inhibition (Hobson et al., 2011). Dolan and Lennox (2013), Fairchild et al. (2009), Van Goozen et al. (2004) and Woltering et al. (2015), on the other hand, did not find cool EF impairments in adolescents with CD and children with ODD or externalizing behaviour. Interestingly, all studies reported hot EF deficiencies (Dolan and Lennox, 2013; Fairchild et al., 2009; Hobson et al., 2011; Syngelaki et al., 2009; Van Goozen et al., 2004; Woltering et al., 2015). Evidence for impairments in hot EF in adolescents with ODD/CD is also found in studies examining decision making by using the Iowa Gambling Task (Bechara et al., 1994). Adolescents with high psychopathic traits (Blair et al., 2001) and adolescents with CD (Ernst et al., 2003) were less likely to avoid risky choices than healthy adolescents.

So far studies have examined hot versus cool EF by comparing different paradigms and studies using similar EF tests but using these in different (typical versus stressful) contexts are needed. Examining how stress affects EF is particularly important in children with ODD/CD, because it may provide information about how their control over thought and behaviour is modulated by stress. The aim of this study was to assess how EF is modulated by an established and ecologically valid psychosocial stressor that involved provocation, frustration and competition to increase emotional arousal in young children with ODD/CD, focusing on working memory, sustained attention, inhibition and cognitive flexibility. In order to meet this aim, we examined EF under typical and under stressful conditions in boys with ODD/CD compared to nonclinical controls (NC). Previous literature found that those with ODD/CD show impairments in hot EF. Therefore, we hypothesized that boys with ODD/CD would perform worse than controls on EF tasks during stress.

EF dysfunctions have also been found in children diagnosed with ADHD or Autism Spectrum Disorder (ASD) (Geurts et al., 2004; Pennington and Ozonoff, 1996), conditions which are often comorbid in children with ODD/CD (Barkley, 2006; Kaat and Lecavalier, 2013). Considering that executive dysfunction may contribute to rigid behaviours, social difficulties, and difficulties in concentration and impulse control, this is not surprising. In order to assess whether EF deficits are not limited to those ODD/CD children with high levels of ADHD symptoms or autism traits, we also examined the relation of EF under typical and stressful conditions and ADHD symptoms and autism traits within the ODD/CD group. Because literature indicates that EF deficits in ODD/CD samples are only found when ADHD comorbidity has not been controlled for, it is hypothesized that both ADHD symptoms and autism traits are inversely related to performance on the EF tasks under typical and stressful conditions.

METHOD

The current study was approved by the Medical Ethical Committee of Leiden University Medical Centre (LUMC). Signed informed consent according to the declaration of Helsinki was obtained prior to participation.

Participants

Participating boys visited Leiden University for one day with one of their parents. During this day parents completed the Diagnostic Interview Schedule for Children (DISC-IV) (Shaffer et al., 2000) and filled out questionnaires, while boys completed computer tasks, some of which were stress inducing. The second session took place approximately two weeks later either at the child's school or the clinical health centre where they were receiving clinical services. This order was fixed because a clinical assessment for inclusion of the study had to take place at the university first. The teacher of the child filled out the Teacher Report Form (TRF/6-18) (Achenbach and Rescorla, 2001) questionnaire.

The ODD/CD group was recruited at clinical health centres (*n*=22), special education schools (*n*=31) and regular elementary schools (*n*=12). For the ODD/CD group (*n*=65) inclusion criteria were a diagnosis of ODD or CD on the DISC-IV (Shaffer et al., 2000), an estimated IQ>70 and age between 8 and 12 years old. They all met criteria for ODD diagnosis and 22 boys (34%) also met CD criteria. Other comorbid diagnoses were: ADHD (*n*=45, 69%), anxiety (*n*=38, 59%), depression (*n*=9, 14%), and other disorders such as eating and tic disorders (*n*=18, 28%), as based on the DISC-IV interview. Twenty boys had severe ASD traits (31%), indicated by score in the clinical range (T>75) on the Social Responsiveness Scale (Constantino and Gruber, 2005). Twenty-five boys (38%) used psychostimulants and four (6%) used atypical antipsychotics.

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Non-clinical control group All boys in the non-clinical control (NC) group (*n*=32) were recruited at regular elementary schools. Inclusion criteria were an estimated IQ>70, age between 8 and 12 years old, no ADHD diagnosis, and no severe aggressive behaviours, expressed as a diagnosis of ODD or CD, a score outside the normal range (T>60) on the externalizing scale of the Child Behavior Checklist (CBCL/6-18) or TRF (Achenbach and Rescorla, 2001).

The ODD/CD group was similar in age (*M*=10.3, *SD*=1.28) and percentage of Caucasians (62%) compared to the NC Group (age *M*=9.9, *SD*=1.24), *t*=1.37, *p*=.174; (Caucasian 66%), χ^2=.15, *p*=.695. The ODD/CD group did have lower estimated IQ scores (*M*= 95.6, *SD*=14.22) than the NC group (*M*= 104.8, *SD*=12.10), *t*=-3.15, *p*=.002.

Measures

Estimated IQ was measured with two subtests of the Wechsler Intelligence Scale for Children (WISC-III) (Wechsler, 2005): Vocabulary and Block Design. They have been found to provide a good estimation of full scale IQ scores (Sattler, 1992).

Executive functioning (EF) Working memory, sustained attention, inhibition and cognitive flexibility were measured using three subtests of the Amsterdam Neuropsychological Tasks (ANT) (De Sonneville, 2012). The ANT exists of a battery of computer tasks and has been used in clinical and non-clinical populations (e.g. Rommelse et al., 2008; Van Rijn and Swaab, 2015) and has satisfactory psychometric properties (De Sonneville, 2005; Huijbregts et al., 2010). Children practiced each task before the actual task started so that their performance was most optimal and learning effects were prevented the second time the task was performed.

Working memory was measured by the Spatial Temporal Span task (De Sonneville, 2012). The parameter used in this study was the number of correctly identified squares in the correct order. Expected score ranges are between 4 to 162, with higher scores indicating better working memory. For a description of the task see van der Meer et al. (2012).

Sustained attention was measured with the Sustained Attention Dots task (De Sonneville, 2012), a continuous performance task. The parameter used in this study is percentage of errors (misses), controlled for average time to completion (response time). For a description of the task see Gunther et al. (2011) and Stins et al. (2005).

Inhibition was measured with the Shifting Attention Set (De Sonneville, 2012). Parameters are average time to completion (response time) controlled for the number of errors. Part 2 was subtracted from part 1. For a description of the task see Bloemsma et al. (2013) and van Deurzen et al. (2012).

Cognitive flexibility was measured with the Shifting Attention Set (De Sonneville, 2012). Parameters are average time to completion (response time) controlled for the number of errors. Part 3 was subtracted from part 1. For a description of the task see Bloemsma et al. (2013) and van Deurzen et al. (2012).

Typical versus stressful condition

The stressful condition was in a nonfamiliar laboratory at Leiden University, using an established and ecologically valid psychosocial stressor that involved provocation, frustration and competition to increase emotional arousal. Boys were led to believe that they were competing against a (videotaped) opponent of similar age and sex for the best performance and a favoured award (for details see Schoorl et al., 2016a; Van Goozen et al., 2000). Three tasks were used to increase emotional arousal. Boys had to complete a simple reaction time computer task in which 16 of the 55 trials were randomly delayed by 6-12 seconds, causing frustration. The opponent gave negative feedback on their performance afterwards. Stress was further induced when boys had to play two competitive computer tasks and were led to believe they were playing against their opponent. First they played the 'Door-opening task' (Daugherty and Quay, 1991), in which boys had to open pre-programmed winning or losing doors. Opening a winning door meant receiving a coin, a losing door returning a coin. They were told that they could stop playing any time they wanted, but had to earn as much money as they could. Second, they played the 'Hungry Donkey task' (Crone and van der Molen, 2004) in which boys had to assist a hungry donkey by winning as many apples as possible by opening one of the four doors. Two doors resulted in gaining more apples than the other two doors, but the losses were also bigger, making them disadvantageous in the long run. After each task, the experimenters exchanged results via an intercom; according to protocol the opponent always had more money/apples, meaning the participant lost both tasks.

After having the boys provoked, frustrated and made them feel of losing out on winning the competition, the three executive functioning tasks were performed. To prevent learning effects, all EF tasks were practiced extensively attaining optimal performance before the actual performance started. There was no more communication with the opponent. Disclosure was done after completion of all EF tests; all boys were told they had won the competition after all and received their prize. None of the boys was aware at the time of testing that the video opponent was not a real participant.

As part of the stress condition, the manipulation of psychological state was checked with an adapted version of the Von Zerssen's clinical self-rating scale (Von Zerssen, 1986) containing eleven moods (happy, well, cheerful, good, liked, satisfied, afraid, worried, embarrassed, ashamed, angry) and feeling of control, which boys rated on a five-point scale ranging from positive towards negative feelings (e.g. 1=happy, 5=gloomy) (see also Van Goozen et al., 2000). All moods were combined into one negative mood score. We also asked boys to rate on a five-point scale who they thought would win the competition (they or the opponent). We used three ratings in time, one before the competition started, one before the EF tasks were administered and one after completion of the EF tasks, but before the competition outcome.

Testing in the typical condition was done in a familiar environment, either at school or at the boy's health centre, approximately two weeks after the stress condition. Testing was done according to typical neuropsychological testing protocols for children, with focus on positive support, re-assurance and efforts to have participants feel comfortable (Baron, 2004). Similar to the stress condition, the EF tasks were practiced extensively before the actual task was performed, thereby preventing learning effects.

Statistical analysis

Some data was missing due to equipment dysfunction or discontinuation of participation in the study. Based on this, sample sizes varied from 97 to 89 boys per analysis. To assess the effect of stress on EF (working memory, sustained attention, inhibition and cognitive flexibility) repeated measures ANOVA's (RANOVA's) were performed with group (ODD/CD versus NC) as between subjects factor and condition (typical versus stress) as within subject factor. Next, within the ODD/CD group a correlation analysis was performed to examine the possible relation between EF under typical and stressful conditions and ADHD symptoms and autism traits. Eta squared (η^2) effect sizes were calculated with 0.02 being a small, 0.13 a medium and 0.26 a large effect (Cohen, 1998).

Results

Because IQ was significantly higher in the NC group than the ODD/CD group a correlation analysis was performed between IQ and the various EF measures. IQ was significantly related to working memory in stress (r=.22, p=.032) and typical conditions (r=.28, p=.007), sustained attention under typical conditions (r=-.25, p=.018), inhibition under typical conditions (r=-23, p=.027) and cognitive flexibility under stress (r=-.42, p<.001) and typical conditions (r=-.23, p=.027). In the following RANOVA's IQ was therefore included as a covariate.

A MANOVA revealed that medication use was not related to the EF measures, F(14,41)=1,21, p=.304. Therefore, medication use was not controlled for in subsequent analyses.

Stress manipulation

First, the effect of the stress manipulation was checked by analysing mood change due to the psychosocial stressor. There was a significant main effect of stress, F(1,92)=38.13, p<.001, with a large effect, η^2=.29, but no effect of group F(1,92)=.04, p=.835, nor was there a stress by group interaction F(1,92)=.72, p=.399. Both the ODD/CD and NC group reported more negative mood when stress was induced (ODD/CD M=1.7 SD=.59, NC M=1.8 SD=.57 vs ODD/CD M=2.5 SD=1.05, NC M=2.4 SD=.92), indicating that stress induction was successful and equal in both groups.

Both groups reported at the beginning of the competition that they thought they would win, which changed during the competition towards the believe that the opponent would win, F(1,89)=53.86, p<.001, with a large effect η^2=.38. There were no group differences F(1,89)=.01, p=.911, and there was no stress by group interaction, F(1,89)=.20, p=.653.

After the last EF task, but before the competition outcome, both groups still reported more negative mood than before the competition F(1,91)=14.93, p<.001, with a medium effect η^2=.14, and were still less confident about winning the competition *F*(1,89)=10.67, *p*=.002, η^2=.11; however, there was again no main effect of group *F*(1,91)=.00, *p*=.976, *F*(1,89)=.09, *p*=.767, or stress by group interaction, *F*(1,91)=.34, *p*=.562, *F*(1,89)=.02, *p*=.895.

Working memory

There was a significant main effect of group, *F*(1,91)=8.45, *p*=.005, η^2=.09, with the ODD/CD group generally performing worse, no effect of condition, *F*(1,91)=.33, *p*=.565, and no condition by group interaction, *F*(1,91)=.32, *p*=.571 (see Fig. 1.1). The covariate IQ did not have a significant effect, *F*(1,91)=.60, *p*=.441 (see Table 1 for *M* and *SD* scores). Post hoc ANCOVA's revealed that the ODD/CD group performed worse under typical conditions, *F*(1,95)=6.20, *p*=.015, η^2=.06, and stress conditions, *F*(1,96)=4.47, *p*=.037, η^2=.05, than controls.

Sustained attention

There was a significant main effect of group, *F*(1,86)=4.79, *p*=.031, η^2=.05, and condition by group interaction, *F*(1,86)=6.47, *p*=.013, η^2=.07, but no effect of condition, *F*(1,86)=.42, *p*=.520 (see Fig. 1.2 and Table 1). There was an effect of the covariate IQ, *F*(1,86)=4.77, *p*=.032 η^2=.05, response time stress condition, *F*(1,86)=39.62, *p*<.001 η^2=.23, and response time typical condition, *F*(1,86)=6.47, *p*=.013 η^2=.07.

Post hoc paired sample t-tests revealed that performance of the ODD/CD group did not differ between stress and typical conditions, *t*=.25, *p*=.805, whilst for the controls it did, *t*=3.84, *p*=.001. Post hoc ANCOVA's revealed that the ODD/CD group only performed worse than the NC group under stressful conditions, *F*(3, 97)=8.49, *p*<.001, η^2=.22, but not under typical conditions, *F*(3, 91)=.17, *p*=.683.

Inhibition

There was a significant condition by group interaction, *F*(1,86)=4.75, *p*=.032, η^2=.05, but no significant effect of condition *F*(1,86)=.03, *p*=.863 or group *F*(1,86)=1.14, *p*=.289 (see Fig. 1.3). This finding was specific for response time (RT), as no significant effects were found when analysing errors (rather than RT) in an additional RANOVA. The covariates IQ *F*(1,86)=.75, *p*=.390 and number of errors stress condition *F*(1,86)=.97, *p*=.327 did not have a significant effect, whereas the number of errors typical condition did, *F*(1,86)=7.79, *p*=.006. For mean and *SD* scores see Table 1.

Post hoc paired sample *t*-tests revealed that the performance of the ODD/CD group was not affected by varying testing conditions, *t*=-1.51, *p*=.136, whereas the NC group responded slower (RT increased) during the stressful condition, *t*= -3.88, *p*=.001. Post hoc ANCOVA's revealed that performance of both groups did not differ from each other under typical conditions, *F*(2,89)=.00, *p*=.993, or under stressful conditions, *F*(3,94)=2.15, *p*=.146.

Cognitive flexibility

There was a significant condition by group interaction *F*(1,86)=6.62, *p*=.012, η^2=.07, but no effect of condition *F*(1,86)=2.10, *p*=.151 or group *F*(1,86)=1.23, *p*=.271 (see Fig. 1.4). Again, this finding was specific for RT, there were no significant effects when analysing errors (rather than RT) in an additional RANOVA. The covariates IQ *F*(1,86)=.69, *p*=.409, number of errors stress condition *F*(1,86)=.49, *p*=.487 and number of errors typical condition, *F*(1,86)=.17, *p*=.682, did not have a significant effect. For mean and *SD* scores see Table 1.

Although post hoc paired samples *t*-tests showed that both the ODD/CD group, *t*=-2.44, *p*=.018, and the NC group, *t*=-4.95, *p*<.001, responded slower during the stressful condition, the interaction effect of the RANOVA indicates that the NC group adapted more. Post hoc ANCOVA's revealed that the ODD/CD group responded faster than the NC group under stressful conditions, *F*(3, 95)=4.45, *p*=.038, η^2=.05, but no differences were found under typical conditions, *F*(3,93)=.17, *p*=.680.

Table 1.

Means, SDs in the ODD/CD and NC groups for executive functioning in typical and stressful test conditions.

		ODD/CD	NC	*Group by condition effect*	*Within group effect*	*Within condition effect*
Working memory	Stress	37.3±17.65	48.2±18.94	*F*(1,91)=.32	*F*(1,91)=8.45	*F*(1,91)=.33
	Typical	38.4±20.86	53.5±19.90	*p*=.571	***p*=.005**	*p*=.565
Sustained attention	Stress	20.1±15.40	9.7±4.27	*F*(1,86)=6.47	*F*(1,86)=4.79	*F*(1,86)=.42
	Typical	20.6±11.84	17.4±12.40	***p*=.013**	***p*=.031**	*p*=.520
Inhibition	Stress	212.6±196.22	286.6±199.17	*F*(1,86)=4.75	*F*(1,86)=1.14	*F*(1,86)=.03
	Typical	172.4±202.27	148.1±184.62	***p*=.032**	*p*=.289	*p*=.863
Cognitive flexibility	Stress	526.4±268.51	621.6±302.54	*F*(1,86)=6.62	*F*(1,86)=1.23	*F*(1,86)=2.10
	Typical	445.0±199.27	401.1±185.12	***p*=.012**	*p*=.271	*p*=.151

Significant effects are in bold

EF during stressful and typical conditions in relation to ADHD symptoms and autism traits

The correlation analysis revealed that EF during stressful and typical conditions was not related to ADHD symptoms or autism traits in boys with ODD/CD (see Table 2).

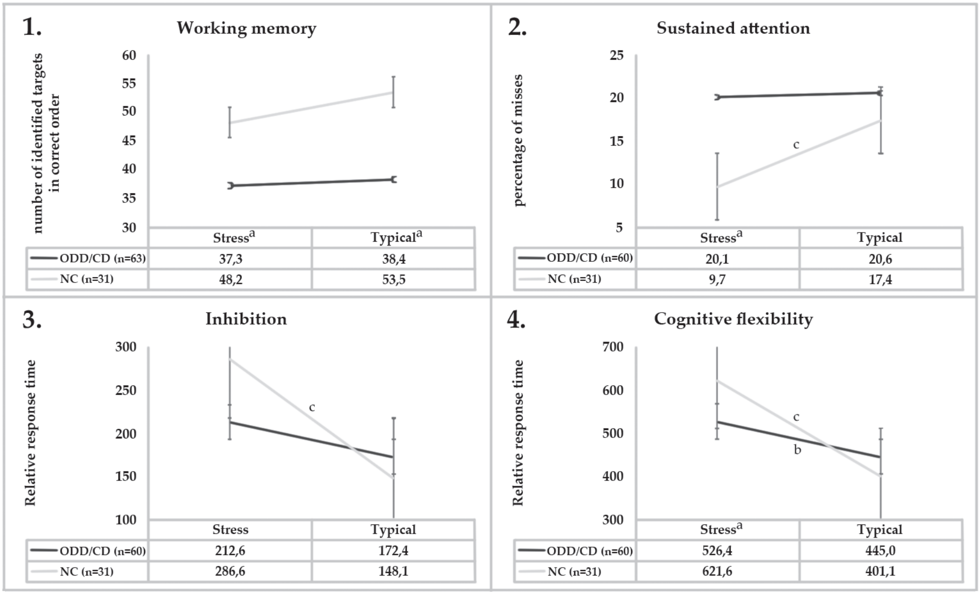

Fig. 1. Increase and decrease of EFs during typical and stressful test conditions in the ODD/CD and NC group. Significant interaction effects were found for sustained attention, inhibition and cognitive flexibility.

a. a significant group difference between ODD/CD and NC group.
b. a significant difference between stressful and typical test conditions in the ODD/CD group.
c. a significant difference between stressful and typical testing conditions in the NC group.

Table 2.
Statistics of the correlation analysis of EF under typical and stressful test conditions and ADHD symptoms and autism traits within the ODD/CD group.

		ADHD symptoms		Autism traits	
		r	*p*	*r*	*p*
Stress	Working memory	-.07	.578	.04	.768
	Attention	-.04	.779	.05	.684
	Inhibition	.02	.907	-.11	.417
	Cognitive flexibility	.07	.583	-.8	.518
Typical	Working memory	-.15	.250	.06	.622
	Attention	.03	.798	.05	.689
	Inhibition	-.09	.473	-.22	.093
	Cognitive flexibility	.00	.971	-.06	.670

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Discussion

The aim of this study was to assess whether boys with ODD/CD have EF impairments, and whether EF is modulated by stress, in boys with ODD/CD, focusing on a broad range of EF domains. These domains were working memory, sustained attention, inhibition and cognitive flexibility. In order to meet this aim, we examined how an established and ecologically valid psychosocial stressor that involved provocation, frustration and competition to increase emotional arousal effects EF in boys with ODD/CD compared to non-clinical controls.

The main finding of this study is that in stressful situations, deficits in adaptation to the environment in boys with ODD/CD became more prominent; whereas typically developing boys showed adaptive changes in EF, this was largely lacking in boys with ODD/CD.

The ODD/CD group showed impairments in working memory in typical conditions. This finding fits with studies from Syngelaki et al. (2009) who reported working memory impairments in young offenders and Séguin (i.e. Séguin et al., 2007; Séguin et al., 2004) who stated that physical aggression and the violent behaviour symptoms of CD are related to working memory deficits; though in two child populations with ODD or externalizing behaviour this was not found (Van Goozen et al., 2004; Woltering et al., 2015). When stress was added, boys with ODD/CD also showed EF impairments in the domain of working memory, and in addition, showed impairments in sustained attention. Thus, under stress, boys with ODD/CD had more impaired EF functioning than typically developing boys. This fits with other studies on hot EF, showing that children with ODD/CD have hot EF impairments (Blair et al., 2001; Dolan and Lennox, 2013; Ernst et al., 2003; Fairchild et al., 2009; Hobson et al., 2011; Syngelaki et al., 2009).

Crucial to our aim of examining how stress impacts EF, the interaction effects showed us that whereas performance in controls in specific domains of EF (sustained attention, inhibition, cognitive flexibility) changed as a result of increasing stress, performance of boys with ODD/CD was less influenced in these domains. Although there was some change in cognitive flexibility, sustained attention and inhibition were not at all influenced by stress in boys with ODD/CD. Self-reports revealed that negative mood was equally induced in both groups, yet their performance in EF tasks differed. These negative emotions may have led to an adaptation in performance of controls, whereas for boys with ODD/CD these negative emotions only influence their performance in cognitive flexibility. Although controls showed longer response times for inhibition and cognitive flexibility in the stressful condition, they did not make more errors. This indicates that they adapted their speed of responding so that they had sufficient time for accurate responses, which is an adaptive response. Taken together, stress resulted in more adaptive responses in the control group, but this was absent in the ODD/CD group for sustained attention and inhibition and to a lesser extend for cognitive flexibility. This finding indicates that boys with ODD/CD may have difficulties in adapting their behaviour to an optimal level in emotional, demanding environments.

Yerkes and Dodson (1908) already described the inverted U shaped relation between arousal and performance. An optimal level of arousal increases performance while too much or too little impairs performance. The finding that boys with ODD/CD did not change their performance in sustained attention and inhibition indicates that they may have different arousal levels than typically developing children, and as a result may not be able to benefit from increased arousal to the same degree as typically developing children. Although in this article we considered boys with ODD/CD as one group, in a previous study (Schoorl et al., 2016a) on variability in arousal levels in boys with ODD/CD, stress induction led to some being overaroused and some being underaroused with distinct relations to behavioural problems. Therefore, the optimal level of arousal might not be the same for all boys with ODD/CD and should be studied in more detail.

One of the main findings of this study is that inducing stress made differences in adaptation visible between boys with ODD/CD and controls. Adding stress had a different effect on sustained attention, inhibition and cognitive flexibility in boys with ODD/CD than controls. This implicates that in complex or emotional situations boys with ODD/CD may experience difficulties in adaptation. Failure to flexibly adapt in complex or changing environments is important for adequate functioning in daily life, and thus may contribute to behavioural problems of those with ODD/CD. This idea is supported by another study in which it was found that boys with ODD/CD made less economic and less adaptive decisions when the situation was ambiguous and emotionally charged (Schoorl et al., 2016b). Emotions are important in guiding behaviour adaptively to the environment (Gross, 1998). One of the mechanisms driving aggressive and antisocial behaviour may therefore be the inability to use emotions in behavioural adaptation. Our findings may have implications for clinical diagnosis and treatment of children with ODD/CD; the findings indicate that the emotional context of behaviour should be taken into account and be a target of support and intervention. Also, future studies examining EF should carefully consider under what circumstance they examine EF. Recently, a study who measured Stroop interference (measuring selective attention and cognitive flexibility) under distressing and neutral emotional stimulation, showed that adolescent males with CD had impaired cognitive control when exposed to distressing emotional stimuli compared to controls, thus when cognitive demand is high, but not when exposed to neutral stimuli (Euler et al., 2014). Woltering et al. (2015) also demonstrated the value of adding emotions to typical cool EF tasks. Their adapted Go-Nogo task proved that only when emotion was induced children with externalizing behaviour performed worse than controls; in the original cool EF Go-Nogo task no differences were found.

EF dysfunction has often also been found in children diagnosed with ADHD or ASD (Geurts et al., 2004; Pennington and Ozonoff, 1996), conditions which are found comorbid in children with ODD/CD (Barkley, 2006; Kaat and Lecavalier, 2013). Considering that executive dysfunctioning may contribute to rigid behaviours, social difficulties, and difficulties in concentration and impulse control, this is not surprising. Therefore, we also examined if ADHD symptoms and autism traits were related to EF within the ODD/CD group. None of the EFs under typical and stressful conditions were related to ADHD symptoms and autism traits. So the EF impairments existed in the ODD/CD group independent of their level of ADHD symptoms and autism traits.

A limitation of this study is that we included only boys. Also, studies on non-clinical children and adolescents indicate that EF, especially hot EF, is still under development into adulthood (Hooper et al., 2004; Prencipe et al., 2011). It would have been interesting if we had expanded our age range to late adolescence, this may have provided us further insights into the impact of stress on EF in relation to ODD/CD. Our design did not allow for counterbalancing the stressful and typical test condition. However, learning effects did not occur since performance was sometimes better in controls (sustained attention) during the first time (i.e. stressful condition) the task was administered.

Taken together we found evidence of EF deficits in boys with ODD/CD and importantly we found that while controls adapted their behaviour in demanding environments, boys with ODD/CD did so only for cognitive flexibility. Failure to adapt behaviour may underlie some of the maladaptive behaviours of boys with ODD/CD in complex and emotionally charged situations, situations that are especially vulnerable to elicit aggressive and antisocial behaviour.