British Journal of Developmental Psychology (2015), 33, 446–463

The British Psychological Society

www.wileyonlinelibrary.com

Executive functions in kindergarteners with high levels of disruptive behaviours

Sébastien Monette[1]*, Marc Bigras[2] and Marie-Claude Guay[2]

[1]Centre Jeunesse de Montréal-Institut Universitaire, Canada
[2]Université du Québec á Montréal, Canada

Executive function (EF) deficits have yet to be demonstrated convincingly in children with disruptive behaviour disorders (DBD), as only a few studies have reported these. The presence of EF weaknesses in children with DBD has often been contested on account of the high comorbidity between DBD and attention-deficit/hyperactivity disorder (ADHD) and of methodological shortcomings regarding EF measures. Against this background, the link between EF and disruptive behaviours in kindergarteners was investigated using a carefully selected battery of EF measures. Three groups of kindergarteners were compared: (1) a group combining high levels of disruptive behaviours and ADHD symptoms (COMB); (2) a group presenting high levels of disruptive/aggressive behaviours and low levels of ADHD symptoms (AGG); and (3) a normative group (NOR). Children in the COMB and AGG groups presented weaker inhibition capacities compared with normative peers. Also, only the COMB group showed weaker working memory capacities compared with the NOR group. Results support the idea that preschool children with DBD have weaker inhibition capacities and that this weakness could be common to both ADHD and DBD.

Executive functions (EFs) can be defined as a set of hypothetical mental processes that allow conscious control of thought and action to orient behaviour towards a future goal (Jurado & Rosselli, 2007). Numerous researchers consider working memory, flexibility, and inhibition to be the principal components of EF (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). It has been hypothesized that these core EFs are relatively distinct, though interrelated. Recent neuroimaging studies have tended to support this model, as the three components have been shown to be associated with relatively distinct brain areas but also to share areas of activation (Collette *et al.*, 2005; McNab *et al.*, 2008). EF deficits have been regularly reported in children with cerebral damage consecutive to medical conditions such as phenylketonuria and sickle cell disease (Azadi, Seddigh, Tehrani-Doost, Alaghband-Rad, & Ashrafi, 2009; Kral, Brown, & Hynd, 2001), traumatic brain injury (Levin & Hanten, 2005), or prenatal exposure to teratogenic agents (Rasmussen, 2005). EF weaknesses have also been reported in children who suffered from severe adverse environmental conditions such as early care deprivation (Stevens *et al.*, 2008). EF deficits have been documented in some neurodevelopmental disorders (Kenworthy, Yerys, Anthony, & Wallace, 2008; Pennington & Ozonoff, 1996), including autism spectrum disorders, Tourette syndrome, and attention-deficit/hyperactivity disorder (ADHD). EF weaknesses have been reported less consistently in children with

**Correspondence should be addressed to Sébastien Monette, 1001 boul. de Maisonneuve est Montréal, Québec , Canada H2L 4R5 (email: sebastien_monette@hotmail.com).*

DOI:10.1111/bjdp.12105

disruptive behaviour disorders (DBDs), that is conduct disorder (CD) and oppositional-defiant disorder (ODD).

This last finding could seem surprising given that, from a theoretical viewpoint, EFs serve to solve complex problems, such as interpersonal conflicts, by inhibiting a dominant response, elaborating a strategy in working memory, and making behavioural flexibility possible, among other things. Investigating EF among children with DBD appears essential in that the presence or absence of an EF weakness in this group could pave the way to complementary methods of intervention. For example, it is rather well established that children with DBD benefit from cognitive-behavioural interventions, especially those centred on the child, such as social skills training, problem-solving skills training, and anger control, and those centred on the parent, such as parenting skills training (Eyberg, Nelson, & Boggs, 2008). However, recent research has shown that children with EF weaknesses could benefit from computer-assisted cognitive remediation and neurofeedback (Lofthouse, Arnold, Hersch, Hurt, & DeBeus, 2011; Rapport, Orban, Kofler, & Friedman, 2013). In this regard, the presence of EF weaknesses in children with DBD, or in a subgroup of such children, might lend support to the idea of diversifying the methods of intervention offered to this population. Moreover, this type of intervention could be most effective during the preschool years, a period sensitive to the development and maintenance of DBD (Tremblay *et al.*, 2004).

EF and DBD

Moffit (1993) reviewed 47 studies of the neuropsychological profile of juvenile delinquents from the period spanning 1965 to 1992 and concluded that these adolescents presented neuropsychological deficits in terms of EF and language skills. In another literature review, Pennington and Ozonoff (1996) showed that for ADHD, the most predictive EF tests were the Tower of Hanoi, motor inhibition tests, and the Matching Familiar Figure Test, which are all centred on the component of inhibitory control. The authors indicated also that while research did evidence EF deficits in children with CD, it did so only when the presence of concurrent ADHD was not controlled. They also asserted that an EF deficit in children with CD (without ADHD) had yet to be proved. Oosterlaan, Logan, and Sergeant (1998), for their part, carried out a meta-analysis demonstrating that the presence of ADHD was strongly associated with weak performance on motor inhibition tests and that children with ADHD did not perform differently on these from children with CD or with a comorbid condition (ADHD + CD). Morgan and Lilienfeld (2000) found in their meta-analysis that antisocial groups in general scored on average 0.62 of a standard deviation below normative (NOR) groups on EF tests. Finally, in their literature review, Sergeant, Geurts, and Oosterlaan (2002) confirmed that an inhibition deficit was present both in children with ADHD and in children with DBD and that, consequently, such impairment was not specific to ADHD. Their review indicated also that neither children with ADHD nor children with CD-ODD presented impaired cognitive flexibility.

Studies undertaken since then have sought to address the limitations noted in previous research, principally by controlling for DBD and ADHD comorbidity. Certain studies thus showed that children with DBD but without ADHD exhibited no EF impairments (Hummer *et al.*, 2010; Oosterlaan, Scheres, & Sergeant, 2005). However, other researchers did observe such impairments (Herba, Tranah, Rubia, & Yule, 2006; Séguin, Boulerice, Tremblay, & Pihl, 1999; Toupin, Déry, Pauzé, Mercier, & Fortin, 2000). In these cases, inhibition was the EF component most often found to be impaired in children with

DBD (Herba *et al.*, 2006; Toupin *et al.*, 2000). What makes it difficult to obtain a clear EF profile for children with DBD (without ADHD) is the fact that researchers to date have normally not measured all three major components of EF and, when they have (Toupin *et al.*, 2000), only one test was used per component.

EF and DBD in preschoolers

In a recent meta-analysis, Schoemaker, Mulder, Deković, and Matthys (2013) demonstrated that preschoolers with externalizing behaviours or disorders exhibited weaker EF capacities, primarily in terms of inhibition. However, these authors were forced to combine studies conducted with children with ADHD and DBD symptoms on account of the small number of existing studies focused specifically on preschoolers with DBD.

Among the few studies that investigated preschoolers with DBD (or a high level of disruptive behaviours) specifically, a first wave of research observed an association between EF and DBD in preschool children as well (Blair, Granger, & Razza, 2005; Brophy, Taylor, & Hughes, 2002; Floyd & Kirby, 2001; Livesey, Keen, Rouse, & White, 2006). Here, too, inhibition was the component most often associated with conduct problems in these young children. However, very few studies have examined other components of EF.

A second wave of research has sought to verify whether this link persisted in young children when comorbid ADHD (or ADHD symptoms) was taken into account. Again, some researchers have found children with DBD to present EF deficits even when ADHD (or ADHD symptoms) was controlled, primarily in the area of inhibition (Raaijmakers *et al.*, 2008; Schoemaker *et al.*, 2012). Other researchers, however, have observed no such relationship (Berlin & Bohlin, 2002; Brocki, Nyberg, Thorell, & Bohlin, 2007; Kalff *et al.*, 2002; Thorell & Wåhlstedt, 2006). Among these, only Raaijmakers *et al.* (2008) and Schoemaker *et al.* (2012) compared their groups on EF scores derived from factor analysis instead of individual test scores. The other researchers did not measure the three major components of EF (Berlin & Bohlin, 2002; Brocki *et al.*, 2007) or, when they did, often used only one test per component (Kalff *et al.*, 2002; Thorell & Wåhlstedt, 2006).

In sum, for school-age children, the presence of EF weaknesses has yet to be demonstrated convincingly, as evidenced by the mixed results reported in the most recent studies in this regard. Various factors might explain these results, including the heterogeneous composition of the clinical groups across studies (e.g., clinical diagnostic of ODD or CD, high level of proactive/reactive aggression, other comorbid conditions) and the methods used to measure EF (e.g., selection of tests to measure each component, choice of scores reported). For preschool-age children, this field of research is still at an emerging stage and is following the same trajectory as with school-age children. However, it is interesting to note that inhibition remains the EF component most often associated with DBD in both age groups, which lends credit to the hypothesis of a specific EF weakness among children with DBD.

EF and ADHD

The presence of an EF deficit in school-age children with ADHD has been fairly well documented. In a vast meta-analytical review (83 studies), Willcut, Doyle, Nigg, Faraone, and Pennington (2005) demonstrated that children with ADHD performed less well than NOR children on the 13 EF tasks selected (moderate global effect size) and that they seemed to perform particularly poorly regarding inhibition, vigilance, spatial working memory and planning capacities. EF weaknesses were not explained by group differences in terms of intelligence or symptoms of other disorders. The authors specified, however, that not all children with ADHD presented EF deficits.

Since this influential review, other studies have been undertaking to corroborate these results. In their meta-analysis, Martinussen, Hayden, Hogg-Johnson, and Tannock (2005) showed that children with ADHD presented impaired working memory. In a more recent meta-analysis, Kasper, Alderson, and Hudec (2012) confirmed that children with ADHD presented considerable difficulties in terms of visuospatial working memory (effect size of .74 across 29 studies) and phonological working memory (effect size of .69 across 34 studies).

However, the presence of an inhibition weakness among children with ADHD has been challenged depending on the method used to measure this component. For example, the meta-analyses by Lijffijt, Kenemans, Verbaten, and van Engeland (2005) and Alderson, Rapport, and Kofler (2007) supported the idea that the poor performance by children with ADHD on inhibition tasks such as the stop-signal task could in fact be explained by a more general attention problem. The inhibition weakness presented by children with ADHD as measured by interference-control tasks, primarily the Stroop task, has often been demonstrated through meta-analyses (Homack & Riccio, 2004; Lansbergen, Kenemans, & van Engeland, 2007; Van Mourik, Oosterlaan, & Sergeant, 2005; for divergent results, see Schwartz & Verhaeghen, 2008). These have shown that, in general, children with ADHD performed less well than their NOR peers on various inhibition tasks. However, some researchers have questioned the validity of the tasks used to measure this EF component.

EF and ADHD in preschoolers

The link between EF and ADHD in preschoolers has drawn the attention of researchers only recently. The meta-analysis by Pauli-Pott and Becker (2011) revealed that children at risk for ADHD presented impaired capacities in terms of inhibition, delay aversion and vigilance (moderate to large effect size), and working memory (weak effect size). The authors mentioned also that the vigilance and interference-control impairments in children at risk for ADHD seemed to grow worse with age.

In sum, regarding the relationship between EF and ADHD, it seems to be established that children with ADHD generally present weaker EF skills than do children from NOR samples, especially with respect to vigilance, working memory, planning, and inhibition. This seems to apply to both school- and preschool-age children, although in their meta-analysis, Pauli-Pott and Becker (2011) suggested that problems with delay aversion were more dominant at first but that, with age, inhibitory control and vigilance problems came to the fore.

Objective

Despite numerous studies and literature reviews, the relationship between EF and DBD remains a matter of debate. A certain number of studies have observed a link between EF, especially inhibition, and the presence of disruptive behaviours when the effect of ADHD was neutralized, but these findings have been too seldom replicated to be irrefutable and, in any event, they have been contradicted by other studies. Where preschool children are concerned, this field of research is still at a very early stage. Against this background, we undertook a study to verify the EF capacities of preschool children at high risk of developing DBD by comparing them with a group of NOR children. We also sought to determine whether preschool children at high risk of presenting both DBD and ADHD differed from NOR children in terms of EF.

We paid special attention to the measurement of EF given that, as reported in the literature review, some methodological shortcomings, including the lack of measures for each EF component and the practice of using only one test per component, have often weakened the conclusions of research on the neurocognition of disruptive disorders (see also Séguin, 2004, for a discussion of this topic). To circumvent these methodological pitfalls, we used a variety of age-appropriate tests to measure three major components of EF: Working memory, flexibility, and inhibition. We also used several tests in the verbal and non-verbal domain for each EF component and EF scores derived from factor analysis in order to estimate the variance common to the tests used to measure each EF component.

Method

Participants

Participants were drawn from a broader longitudinal study of the effects of an intervention programme targeting externalizing behaviours (inattention, impulsivity, hyperactivity, aggressive [AGG] behaviours, and opposition behaviours) in kindergarteners. The NOR group consisted of 85 children (39 boys, 46 girls) attending kindergarten in the suburban region of Sherbrooke or the urban region of Montréal (province of Québec, Canada). The children were recruited in 24 regular classes across 15 regular primary schools.

The AGG group (high level of AGG behaviours, $n = 17$) and the combined (COMB) group (high level of AGG behaviours and high level of ADHD behaviours, $n = 17$) were drawn from a larger sample of ‘at-risk’ children ($n = 71$) presenting high levels of externalizing behaviours. This ‘at-risk’ sample was itself drawn from a larger NOR sample ($N = 475$). Children in this baseline sample were recruited in 49 regular classes across 39 regular schools. Children in the at-risk sample were selected from among the children of the baseline sample by means of the Fluppy screening questionnaire, an instrument developed for a larger research project (Poulin *et al.*, 2013). The Fluppy screening questionnaire included 18 items on (1) ODD and CD (5 items), (2) attention-deficit/hyperactivity disorder (6 items), (3) direct aggression (4 items), and (4) indirect aggression (3 items). For each item, the response format offered respondents three choices: (0) ‘never or not true’, (1) ‘sometimes or somewhat true’, and (2) ‘often or very true’. The total score for this instrument ranged from 0 to 36. Children whose total score ranged beyond the 65th percentile according to both teacher and parent were selected to be part of the at-risk sample. About 15% of all children in the sample met this criterion ($n = 71$). The aim of this preliminary screening was essentially to identify children showing above-average levels of DBD and ADHD behaviours in their two principal life settings, namely at home and at school. This procedure allowed us to exclude children who might exhibit difficulties in one setting only, which could be tied more to a parent–child or teacher–child relational problem than to a problem with the child per se, which would instead be expressed in various settings.

We next formed two groups: one with a high level of DBD behaviour (AGG group) and another with a high level of both DBD and ADHD behaviour (COMB group). Given that the prevalence of ADHD is estimated at 5–10% (Polanczyk, Willcutt, Salum, Kieling, & Rohde, 2014), the at-risk sample ($n = 71$) was then split along the 90th-percentile cut-off on the attention problem scale (covering symptoms of inattention, hyperactivity, and impulsivity) of the Achenbach System of Empirically Based Assessment – Teacher Report Form (ASEBA-TRF) to minimize the chances of having a child with ADHD end up in the AGG group. In the two groups of children, we kept only those we could match exactly in terms of their scores on the AGG behaviour scale (covering symptoms of ODD and CD) of the ASEBA-TRF (see Table 1 for details).

Procedure

We asked school boards to explain the project to their school principals. If interested, the principals then provided information for contacting their kindergarten teachers. Kindergarten teachers were contacted and, if they expressed an interest in participating in the study, a letter was sent to the parents of the children in their classes to solicit their participation and obtain their informed consent. In the winter, questionnaires were sent to the teachers of the participating children. Then, the families of these children were visited at home by two research assistants. On this occasion, one research assistant helped the parents complete various questionnaires and the other assistant administered the various tests to the child in a separate room. Children received a small toy (10$ value) as a token of appreciation for their participation. For the COMB and AGG groups, the procedure was the same, except that the Fluppy screening questionnaire was first sent to the teacher and the parents to solicit only families with an at-risk child. The research project was approved by the Ethics Review Board of Université du Québec à Montréal (UQAM). The project began 2 months after the start of the school year (November) to allow the teachers to get to know the children better and thus be able to complete the questionnaires better.

Measures

Working memory

Backward word span. In this test, the experimenter read out sequences of 2, 3, and 4 monosyllabic words (4 sequences of each length for 12 in all). Children had to repeat the sequence backward. The score reported is the number of correct sequences given (range 0–12).

Backward block span. This test was similar to the one found in the Wechsler Memory Scale (WMS), but with only eight target blocks. The blocks were mounted on a pedestal, and the experimenter pointed out a sequence. Children then had to reproduce the sequence in reverse. Sequences varied from two to five items (three of each length for 12 in all). The score reported is the number of correct sequences given (range 0–12).

Flexibility

Trails-P. There were two conditions to this task adapted from Espy and Cwik (2004). In the first condition, we gave children an 11×17 sheet of paper with the five mice, and we asked them to draw a trail with a pencil of their choice to connect the five mice in order of size from smallest to biggest. In the second condition, we gave children another sheet of paper with the same five mice and five pieces of cheese corresponding in size and colour to the mice. We again asked children to draw a trail from the smallest to the biggest mouse,

Table 1. Sample descriptive statistics ($n = 119$)

Variable	COMB group		AGG group		NOR group		ANOVAS/*t*-test	*Post-hoc*
	M	*SD*	M	*SD*	M	*SD*	F/t	Scheffe
N	17	–	17	–	85	–	–	
Sex ratio (boys:girls)	11:6	–	9:8	–	39:46	–	–	
Age (months)	69.00	3.06	68.29	4.32	70.32	4.13	ns	
Maternal education	13.32	3.21	13.29	3.31	14.15	3.16	ns	
Family income	4.41	2.79	5.76	2.25	5.73	2.14	ns	
SCBE social competence[a]	2.94	0.54	3.14	0.76	3.94	0.83	$F(2, 33) = 22.41^{**}$	COMB, AGG < NOR
SCBE anger-aggression	3.43	0.94	3.22	0.97	1.80	0.66	$F(2, 116) = 50.16^{**}$	COMB, AGG > NOR
SCBE anxiety-withdrawal[a]	2.45	1.07	3.14	0.76	1.89	0.67	ns	
ASEBA TRF agg	67.41	5.01	67.41	5.01	na	na	$t(32) = 0.00$	
ASEBA TRF adhd	68.35	5.72	58.12	3.60	na	na	$t(32) = 6.26^{**}$	

Note. COMB group, combined group; AGG group, aggressive group; NOR group, normative group; Maternal education, mother's education (in years); Family income, family income (Likert scale 1–8); ASEBA TRF agg, T score on the aggressive behavior scale of the ASEBA teacher report form; ASEBA TRF adhd, T score on the attention problems scale of the ASEBA teacher report form; SCBE, Social Competence and Behavior Evaluation scales; na, not available.

[a]For those variables, Levene's test revealed unequal variance between groups consequently, and Welch (*F*) and Games–Howell (*post-hoc*) statistics are reported.

$^{**}p < .01$.

connecting with each mouse's cheese before proceeding to the next mouse. If children committed an error, the experimenter pointed it out and had them resume from the last correct location. The score reported is the number of intraclass errors in the second condition, that is the number of times the child tried to connect a mouse directly to another mouse or a piece of cheese to another piece of cheese (range 0–2).

Card sort. This flexibility test has previously been described by Hughes (1998a,b). In this task, children must sort a series of cards presented by trying to guess which ones are the favourite cards of a teddy bear. After each response, the experimenter gives children feedback (right/wrong answer) to allow them to figure out the sort rule. The test comprises two conditions, both involving a different teddy bear and a different pack of 20 cards with one of two shapes (square or triangle in condition 1; circle or star in condition 2) in one of two colours (red or green in condition 1; blue or yellow in condition 2). The score reported is a perseveration score (range 0–7).

Inhibition

Day–night test. We used the same task described in Gerstadt, Hong, and Diamond (1994). A series of 24 cards was presented to children, one at a time. Children had to say 'night' when the experimenter presented a card with a blue sky and a sun, and 'day' when the experimenter presented a card with a moon on a black background. Reported are the number of uncorrected errors and the number of self-corrected errors (range 0–24 for each).

Fruit Stroop. We adapted this task from the fruit Stroop developed by Archibald and Kerns (1999) for school-age children, which did not involve reading skills. In this version, there were only two types of fruit (apples and bananas) and two colours (yellow and red). The test consisted of four conditions with four corresponding pages of stimuli. In the first condition, the experimenter showed children a page with coloured squares (four rows of five, for a total of 20 per page). Children were told to name the colour of the squares (yellow or red) as quickly as possible in 45 s. If children completed the page within the time limit, they were instructed to continue at the top of the page. If they made a mistake, the experimenter pointed it out and children had to correct themselves. In the second condition, children were presented a page with red apples and yellow bananas. Children had to name the colours of the fruits. In the third condition, children were presented a page with the same fruit, but with no colour. Children were again asked to name the colour of the fruit. In the fourth condition, children were presented the same fruits, but some were not the right colour (red bananas and yellow apples). Children were instructed to name the colour the fruit would normally be 'in real life'. Reported are the number of fruit colours correctly named and the number of errors made in the fourth (interference) condition (range 4–48 for correct responses; 0–10 for errors).

Knock and tap. This task was part of the first edition of the NESPY battery. It comprises two conditions. First, children must knock with a closed fist on the table whenever the experimenter taps on the table with the palm of the hand and vice versa, for 15 items arranged in a pseudorandom order. In the second condition, children must abide by a rule change and pound the table with the side of the hand whenever the experimenter knocks on the table with a closed fist and vice versa. If the experimenter taps the table with the palm of the hand, then children must stay still. This second condition has 15 items as well. The test was scored as follows: children were given 2 points for a correct answer, 1 point for a self-corrected error, and 0 for an error. Total scores for conditions 1 and 2 are reported (range 0–30 for each).

Behavioural rating of ADHD and disruptive behaviours

Achenbach System of Empirically Based Assessment – Teacher Report Form

The 113-item ASEBA-TRF (Achenbach & Rescorla, 2001) was completed by the teachers of the children in 'at-risk' sample ($n = 71$). The respondent is asked to rate the frequency of behaviours in a child on a 3-point Likert scale (0 = never, 1 = sometimes, 2 = often or always). The attention problems scale (26 items) and AGG behaviour scale (20 items) are reported as a t score (mean = 50; $SD = 10$).

Social Competence and Behavior Evaluation – 30 items

The Social Competence and Behavior Evaluation – 30 items (SCBE-30; LaFreniere & Dumas, 1996) is divided into three 10-item subscales: anger-aggression, anxiety-withdrawal, and social competence. In this study, the SCBE-30 was completed by the kindergarten teacher. The questionnaires were only sent out at least 3 months into the school year to ensure that teachers had become familiar with the children. The SCBE scores were meant to serve as a behavioural measure for comparing the NOR group with the two other groups, given that the ASEBA-TRF was used with the AGG and COMB groups only.

Sociodemographic data

A standard sociodemographic questionnaire was filled out by the children's parent(s). Data concerning family structure, family income, parent's education, employment status, and ethnicity were collected through this instrument. Mother's education corresponded to the number of years of schooling completed, and family income was reported on a Likert scale from 1 to 8 (i.e., $0–10K, $10–20K, $20–30K, $30–40K, $40–50K, $50–60K, $60–80K, and $80K or more).

Data reduction

The data were analysed using SPSS 17.0 (SPSS Inc., Chicago, IL, USA). The scores yielded by the battery of EF tests were subjected to an exploratory factor analysis in an attempt to extract from them more refined and, therefore, more valid EF indicators. Certain scores were subjected to a transformation (square root or $\log_{10}$) to reduce skewness, a common problem in the evaluation of EF in young children. Of 10 scores, 6 had to be transformed (day–night test uncorrected errors and self-corrected errors, trails-p switch errors, card-sort perseveration score, knock-and-tap conditions 1 and 2) to meet the criteria for normality and linearity necessary for subsequent analyses. Then, some scores were inverted (multiplied by -1) so that all high scores would indicate competence in the test, to facilitate the interpretation of the factors. Factors with eigenvalues >1 were retained. The oblimin rotation method was used beforehand given that EFs tend to correlate with one another. The regression method was used to estimate the factor coefficients that would serve as indicators of working memory, flexibility, and inhibition capacity. The score for each factor (mean = 0, $SD = 1$) is a linear combination of all of the measures, weighted by the corresponding factor loading.

Results

Descriptive statistics

The characteristics of the three groups under study are presented in Table 1. The three groups did not differ on any sociodemographic variable. Levene's test of homogeneity of variance proved significant for the SCBE social competence and anxiety-withdrawal subscales. For these two variables, the Welch and Games–Howell statistics were used. As expected, the COMB group and the AGG group showed a higher level of anger-aggression, $F(2, 116) = 50.16$, $p < .01$, and a lower level of social competence, $F(2, 33) = 22.41$, $p < .01$, compared with their NOR peers, as rated by their kindergarten teachers on the SCBE.

Factor structure

Table 2 presents the correlations across EF test scores, and Table 3, the oblimin-rotated factor loadings. Three factors emerged, explaining 32%, 12%, and 11% of the variance of the EF tests: variables known to be related to working memory (backward block span and backward word span), fruit Stroop total score, and day–night test uncorrected errors loaded on the first factor; the two flexibility tests (trails-P and card sort) loaded on the second factor; and, finally, the other scores related to inhibition (day–night test self-corrected errors, fruit Stroop errors, knock-and-tap conditions 1 and 2) loaded on the third

Table 2. Correlations among executive function tests ($n = 119$)

Variable	1	2	3	4	5	6	7	8	9
1. Bword	–	–							
2. Bbloc	.52 **	–							
3. DNerr[a]	.36 **	.31 **	–						
4. DNscerr[a]	.11	.23 *	.15	–					
5. Fruittot	.50 **	.41 **	.37**	.24**	–				
6. Fruiterr	.19 *	.25 **	.06	.21 *	.33 **	–			
7. Knockl[a]	.19 *	.25 **	.13	.22 *	.33 **	.32**	–		
8. Knock2[a]	.21 *	.38 **	.23 *	.19 *	.31 **	.25 **	.44**	–	
9. Trails	.14	.20 *	–.02	.09	.11	.05	–.03	.01	–
10. Card sort[a]	.25 **	.32**	.15	.14	.21 *	.19 *	.30	.23*	.23*

Notes. Bword, backward word span; Bbloc, backward bloc span; DNerr, day–night test uncorrected errors; DNscerr, day–night test self-corrected errors; Fruittot, fruit Stroop total; Fruiterr, fruit Stroop errors; Knockl, knock and tap condition 1; Knock2, knock-and-tap condition 2; Trails: trails-p switch errors; Card sort, card sort perseveration score.
[a]Variables transformed using a log procedure to meet normality requirement.
$*p < .05$; $**p < .01$.

Table 3. Factor analysis pattern matrix for executive functions tests (n = 119)

	Factor loading		
Executive function test scores	1 (WM)	2 (FLEX)	3 (INH)
Day–night test (uncorrected errors)	**.81**	−.22	−.09
Backward word span	**.80**	.17	−.07
Fruit Stroop (total)	**.62**	.01	.26
Backward block span	**.59**	.28	−.18
Trails-P (switch errors)	.00	**.90**	−.16
Card sort (perseveration)	.07	**.51**	.34
Knock and tap (step 1 score)	−.05	−.12	**.83**
Fruit Stroop (errors)	−.06	.05	**.67**
Knock and tap (step 2 score)	.17	−.13	**.65**
Day–night test (self-corrected errors)	.03	.09	**.46**
Factor correlations			
Factor 1	–		
Factor 2	.15	–	
Factor 3	.35**	.19*	–

Note. Values >0.40 are highlighted in bold.
WM, working memory; FLEX, flexibility; INH, inhibition.
*$p < .05$; **$p < .01$.

factor. Composite scores were then created using the factor loadings. We named factor 1 ‘working memory’ (WM), factor 2 ‘flexibility’ (FLEX), and factor 3 ‘inhibition’ (INH), although it needs to be said that the variables that made up factor 1 included measures of both WM and inhibition. Concerning the *day–night test errors* variable, its association with the WM factor could be due to goal neglect. Indeed, children who lose sight of what they are supposed to do during the day–night test inevitably obtain a very high error score and a very low self-corrected error score. In this regard, some authors (Kane & Engle, 2003) have evidenced that individuals with low WM capacity committed a greater number of goal-neglect errors. As for the ‘fruit Stroop total score’, a time score might not be the best indicator of inhibition capacity. In this regard, Van der Ven, Kroesbergen, Boom, and Leseman (2013) demonstrated that time scores on interference-control tasks reflected information-processing speed and not inhibition. In the light of the strong correlation between WM and information-processing speed, it is not surprising that the ‘fruit Stroop total score’ loaded here on the WM factor. We maintained the oblimin rotation given that INH was significantly correlated with WM (r = .35, $p < .01$) and to a lesser extent with FLEX (r = .19, $p < .05$).

Group comparisons

We next compared the three groups on the three EF factors (WM, FLEX, and INH) using one-way ANOVAs. Levene’s test did not prove significant, indicating that the variance was homogeneous across the three groups on the three factors. Table 4 gives the results of these analyses, and Figure 1 illustrates the group means for the three factors. The one-way ANOVA regarding the dependent variable WM proved significant, $F(2, 116) = 6.14$, $p < .01$, as did the one-way ANOVA regarding the dependent variable INH, $F(2, 116) = 13.10$, $p < .01$. The three groups did not differ on the FLEX variable. The *post-hoc*

Table 4. ANOVAS and *post-hoc* tests

Executive function factors	COMB group		AGG group		NOR group		ANOVAS	*Post-hoc*
	M	*SD*	M	*SD*	M	*SD*	F	Scheffe
Working memory factor	−0.73	1.17	−0.09	0.77	0.16	0.95	$F(2, 116) = 6.14^{**}$	COMB < NOR
Flexibility factor	0.01	1.06	−0.24	0.93	0.05	1.00	$F(2, 116) = 0.61$	–
Inhibition factor	−0.61	0.99	−0.74	0.95	0.27	0.89	$F(2, 116) = 13.10^{**}$	COMB, AGG < NOR

Note. COMB group, combined group; AGG group, aggressive group; NOR group, normative group.
$^{**}p < .01$.

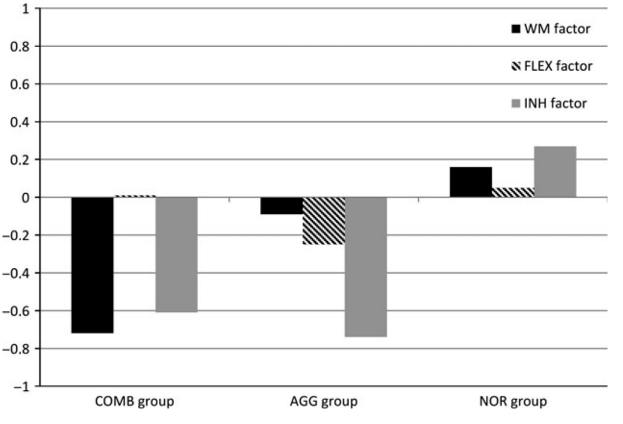

Figure 1. Group means for the EF factors. *Note.* EF, executive function; WM, working memory; FLEX, flexibility; INH, inhibition; COMB group, combined group; AGG group, aggressive group; NOR group, normative group. Each EF factor (mean = 0, *SD* = 1) is a linear combination of all of the measures, weighted by the corresponding factor loading.

tests, in our case Scheffe's tests, revealed a large significant difference between the COMB group and the NOR group on the WM variable (Cohen's $d = 0.84$). Regarding the INH variable, the NOR group proved significantly different from both the COMB and the AGG groups. These differences, too, could be considered large (Cohen's $d = 0.93$ and 1.10, respectively).

Discussion

The main objective of our study was to investigate the EF profile of kindergarteners presenting high levels of disruptive behaviours with high or low levels of ADHD symptoms. To this end, we used an optimal strategy for measuring EF, that is one that took into account the methodological shortcomings of earlier studies. The children's performances on the EF tests support a three-component model of EF (i.e., WM, FLEX, and INH). Although some studies conducted with samples of preschool children initially supported a 1-factor EF model (Espy, Sheffield, Wiebe, Clark, & Moehr, 2010), recent studies indicate that it is possible to distinguish different dimensions of EF in young children when the battery of tasks used covers several EF components correctly (Miller, Giesbrecht, Müller, McInerney, & Kerns, 2012). Our results indicate that kindergarteners with high levels of disruptive behaviours and lower levels of ADHD symptoms (AGG group) demonstrate weaker inhibition capacities compared with NOR children. Kindergarteners with high levels of disruptive behaviours and ADHD symptoms (COMB group) have weaker inhibition and working memory capacities compared with NOR peers (NOR group).

These results thus support the idea that children with DBD are characterized by an inhibition weakness and that this weakness is already present in the preschool years. Raaijmakers *et al.* (2008) and Schoemaker *et al.* (2012) obtained results similar to ours. However, other studies of preschool children found no EF deficits in children with disruptive behaviours (Berlin & Bohlin, 2002; Brocki *et al.*, 2007; Kalff *et al.*, 2002; Thorell & Wåhlstedt, 2006). These results might be explained by the composition of the clinical or at-risk groups in these studies, though. In our study as in Raaijmakers *et al.* (2008) and Schoemaker *et al.* (2012), the groups of children with high levels of disruptive behaviours were defined as a function of their score on the ASEBA AGG behaviour scale, unlike other studies where the groups of children with disruptive behaviours were defined on the basis of an ODD diagnosis or high levels of ODD behaviours. The ASEBA AGG behaviour scale covers several symptoms of ODD but also various symptoms of CD, particularly those related to physical aggression and destruction (e.g., destroys his/her own things, destroys property belonging to others, gets in many fights, physically attacks people). Consequently, the children with disruptive behaviours selected by our team, Raaijmakers *et al.* (2008) and Schoemaker *et al.* (2012), might have presented more severe behavioural and emotional problems, including physical aggression and destructive behaviours, and it is possible that these aspects of disruptive behaviour at a young age are more related to an EF weakness than to oppositional behaviours. Consequently, it is possible that an inhibition weakness is present in only a subgroup of children with DBD or at risk of developing DBD. In this regard, some researchers have obtained results that support this idea. For example, Barker *et al.* (2011) demonstrated that of the behaviours associated with CD, those related to physical aggression were associated with neurocognitive deficits, which was not the case for theft-related behaviours. Similarly, some researchers have shown the link between EF and AGG behaviours to be significant only in the case of reactive aggression (Feilhauer, Cima, Korebrits, & Kunert, 2012; Giancola, Moss, Martin, Kirisci, & Tarter, 1996) or in children with a hostile attribution bias (Ellis, Weiss, & Lochman, 2009).

The presence of an inhibition weakness among children with DBD lends support also to the idea that children with DBD and those with ADHD might present a common neuropsychological dysfunction. Inhibition tests make demands on various regions of the brain, including the anterior cingulate cortex (BA 32), the dorsolateral prefrontal cortex (BA 9, 46), the inferior prefrontal cortex (BA 44, 45, 47), the posterior parietal cortex, and the anterior insula (Nee, Wager, & Jonides, 2007). Brain lesion studies have shown that the right inferior frontal cortex plays an essential role in the successful execution of inhibition tasks (Aron, Robbins, & Poldrack, 2004). In a review of the neuroimaging literature, Rubia (2011) demonstrated that ADHD and CD were disorders implicating distinct neurophysiological dysfunctions, with ADHD associated with a dysfunction of the inferior fronto-striatal–cerebellar and parietotemporal regions regulating attention and cognition, and CD associated instead with a dysfunction of the paralimbic system including the orbitofrontal cortex, the superior temporal lobes, and underlying limbic structures, as well as with a frontolimbic ventromedial abnormality. Rubia (2011) mentioned, however, that some dysfunctions could be common to both disorders, including those of the limbic–ventromedial region, the mesolimbic pathway, and the anterior cingulate cortex. An inhibition deficit common to ADHD and DBD could thus reflect such a common brain dysfunction.

As for flexibility capacities, our results are in line with the majority of previous studies conducted with school-age children (Sergeant *et al.*, 2002) and preschoolers (Pauli-Pott & Becker, 2011), which indicate that children with ADHD or DBD do not present a cognitive flexibility deficit. Our results do show, however, that AGG preschoolers with ADHD symptoms have poorer WM capacity, notwithstanding our admission that our WM factor might not be determined solely by WM and could be influenced by processing speed and goal neglect. These results do not concur, however, with those of the meta-analysis by Pauli-Pott and Becker (2011), which showed working memory to be the EF component least affected in the presence of ADHD symptoms in preschool children. We believe that this can be explained by the fact that most tasks measuring the WM component in the studies reviewed by Pauli-Pott and Becker were in fact short-term memory or memory span (passive storage) tasks rather than what are generally understood to be WM or central executive WM tasks, that is those that involve storing and updating/manipulating information (active storage; for a detailed discussion of the matter, see Kasper *et al.*, 2012). In this regard, Martinussen *et al.* (2005) demonstrated that WM was significantly more affected in children with ADHD than was short-term memory or memory span.

The strengths of our study lie primarily in the effort made to measure EF in a detailed, thorough, and optimal manner. However, the study is not without its limits, uppermost among these being a small sample size. The children in the NOR and COMB groups did not present a clear ADHD, CD, or ODD diagnosis, which has often been the case for samples of preschool-age children in other studies. This sets a limit on the generalization of results to clinical groups. Future research will need to (1) pay special attention to the selection of clinical or at-risk groups, (2) use measures that will allow distinguishing proactive aggression behaviours, reactive aggression behaviours, and callous-unemotional traits, and (3) include a selection of measures that cover the three principal EF components. Studies of the sort will allow us to gain a better understanding of the relationship between DBD and EF, their respective development, and their reciprocal influence.

Acknowledgements

This research was supported by the Social Sciences and Humanities Research Council (SSHRC) of Canada (grant no. 410-2006-2496). The authors would like to thank the families, teachers, and research assistants who participated in this study.

References

Achenbach, T. M., & Rescorla, L. A. (2001). *Manual for the ASEBA school-age forms & profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.

Alderson, R., Rapport, M., & Kofler, M. (2007). Attention-deficit/hyperactivity disorder and behavioral inhibition: A meta-analytic review of the stop-signal paradigm. *Journal of Abnormal Child Psychology*, *35*, 745–758. doi:10.1007/s10802-007-9131-6

Archibald, S. J., & Kerns, K. A. (1999). Identification and description of new tests of executive functioning in children. *Child Neuropsychology*, *5*, 115–129.

Aron, A. R., Robbins, T. W., & Poldrack, R. A. (2004). Inhibition and the right inferior frontal cortex. *Trends in Cognitive Sciences*, *8*, 170–177. doi:10.1016/j.tics.2004.02.010

Azadi, B., Seddigh, A., Tehrani-Doost, M., Alaghband-Rad, J., & Ashrafi, M. (2009). Executive dysfunction in treated phenylketonuric patients. *European Child & Adolescent Psychiatry*, *18*, 360–368. doi:10.1007/s00787-009-0738-8

Barker, E. D., Tremblay, R. E., van Lier, P. A. C., Vitaro, F., Nagin, D. S., Assaad, J.-M., & Séguin, J. R. (2011). The neurocognition of conduct disorder behaviors: Specificity to physical aggression and theft after controlling for ADHD symptoms. *Aggressive Behavior*, *37*, 63–72. doi:10.1002/ab.20373

Berlin, L., & Bohlin, G. (2002). Response inhibition, hyperactivity, and conduct problems among preschool children. *Journal of Clinical Child & Adolescent Psychology*, *31*, 242–251. doi:10.1207/S15374424JCCP3102_09

Blair, C., Granger, D., & Razza, P. (2005). Cortisol reactivity is positively related to executive function in preschool children attending Head Start. *Child Development*, *76*, 554–567. doi:10.1111/j.1467-8624.2005.00863.x

Brocki, K. C., Nyberg, L., Thorell, L. B., & Bohlin, G. (2007). Early concurrent and longitudinal symptoms of ADHD and ODD: Relations to different types of inhibitory control and working memory. *Journal of Child Psychology and Psychiatry*, *48*, 1033–1041. doi:10.1111/j.1469-7610.2007.01811.x

Brophy, M., Taylor, E., & Hughes, C. (2002). To go or not to go: Inhibitory control in 'hard to manage' children. *Infant and Child Development*, *11*, 125–140. doi:10.1002/icd.301

Collette, F., van der Linden, M., Laureys, S., Delfiore, G., Degueldre, C., Luxen, A., & Salmon, E. (2005). Exploring the unity and diversity of the neural substrates of executive functioning. *Human Brain Mapping*, *25*, 409–423. doi:10.1002/hbm.20118

Ellis, M., Weiss, B., & Lochman, J. (2009). Executive functions in children: Associations with aggressive behavior and appraisal processing. *Journal of Abnormal Child Psychology*, *37*, 945–956. doi:10.1007/s10802-009-9321-5

Espy, K. A., & Cwik, M. F. (2004). The development of a trail making test in young children: The TRAILS-P. *The Clinical Neuropsychologist*, *18*, 411–422. doi:10.1080/138540409052416

Espy, K. A., Sheffield, T. D., Wiebe, S. A., Clark, C. A. C., & Moehr, M. J. (2010). Executive control and dimensions of problem behaviors in preschool children. *Journal of Child Psychology and Psychiatry*, *52*, 33–46. doi:10.1111/j.1469-7610.2010.02265.x

Eyberg, S. M., Nelson, M. M., & Boggs, S. R. (2008). Evidence-based psychosocial treatments for children and adolescents with disruptive behavior. *Journal of Clinical Child & Adolescent Psychology*, *37*, 215–237. doi:10.1080/15374410701820117

Feilhauer, J., Cima, M., Korebrits, A., & Kunert, H.-J. (2012). Differential associations between psychopathy dimensions, types of aggression, and response inhibition. *Aggressive Behavior*, *38*, 77–88. doi:10.1002/ab.20415

Floyd, R. G., & Kirby, E. A. (2001). Psychometric properties of measures of behavioral inhibition with preschool-age children: Implications for assessment of children at risk for ADHD. *Journal of Attention Disorders*, *5*, 79–91. doi:10.1177/108705470100500202

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3½–7 years old on a Stroop-like day-night test. *Cognition*, *53*, 129–153. doi:10.1016/0010-0277(94)90068-X

Giancola, P. R., Moss, H. B., Martin, C. S., Kirisci, L., & Tarter, R. E. (1996). Executive cognitive functioning predicts reactive aggression in boys at high risk for substance abuse: A prospective study. *Alcoholism: Clinical and Experimental Research*, *20*, 740–744. doi:10.1111/j.1530-0277.1996.tb01680.x

Herba, C. M., Tranah, T., Rubia, K., & Yule, W. (2006). Conduct problems in adolescence: Three domains of inhibition and effect of gender. *Developmental Neuropsychology*, *30*, 659–695. doi:10.1207/s15326942dn3002_2

Homack, S., & Riccio, C. A. (2004). A meta-analysis of the sensitivity and specificity of the Stroop Color and Word Test with children. *Archives of Clinical Neuropsychology*, *19*, 725–743. doi:10.1016/j.acn.2003.09.003

Hughes, C. (1998a). Executive function in preschoolers: Links with theory of mind and verbal ability. *British Journal of Developmental Psychology*, *16*, 233–253. doi:10.1111/j.2044-835X.1998.tb00921.x

Hughes, C. (1998b). Finding your marbles: Does preschoolers' strategic behavior predict later understanding of mind? *Developmental Psychology*, *34*, 1326–1339. doi:10.1037/0012-1649.34.6.1326

Hummer, T. A., Kronenberger, W. G., Wang, Y., Dunn, D. W., Mosier, K. M., Kalnin, A. J., & Mathews, V. P. (2010). Executive functioning characteristics associated with ADHD comorbidity in adolescents with disruptive behavior disorders. *Journal of Abnormal Child Psychology*, *39*, 1–9. doi:10.1007/s10802-010-9449-3

Jurado, M. B., & Rosselli, M. (2007). The elusive nature of executive functions: A review of our current understanding. *Neuropsychology Review*, *17*, 213–233. doi:10.1007/s11065-007-9040-z

Kalff, A. C., Hendriksen, J. G. M., Kroes, M., Vles, J. S. H., Steyaert, J., Feron, F. J. M., . . . Jolles, J. (2002). Neurocognitive performance of 5- and 6-year-old children who met criteria for attention deficit/hyperactivity disorder at 18 months follow-up: Results from a prospective population study. *Journal of Abnormal Child Psychology*, *30*, 589–598. doi:10.1023/A:1020859629994

Kane, M. J., & Engle, R. W. (2003). Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General*, *132*, 47–70. doi:10.1037/0096-3445.132.1.47

Kasper, L. J., Alderson, R. M., & Hudec, K. L. (2012). Moderators of working memory deficits in children with attention-deficit/hyperactivity disorder (ADHD): A meta-analytic review. *Clinical Psychology Review*, *32*, 605–617. doi:10.1016/j.cpr.2012.07.001

Kenworthy, L., Yerys, B. E., Anthony, L. G., & Wallace, G. L. (2008). Understanding executive control in autism spectrum disorders in the lab and in the real world. *Neuropsychology Review*, *18*, 320–338. doi:10.1007/s11065-008-9077-7

Kral, M., Brown, R., & Hynd, G. (2001). Neuropsychological aspects of pediatric sickle cell disease. *Neuropsychology Review*, *11*, 179–196. doi:10.1023/A:1012901124088

LaFreniere, P. J., & Dumas, J. E. (1996). Social competence and behavior evaluation in children ages 3- to 6-years: The short form (SCBE-30). *Psychological Assessment*, *8*, 369–377. doi:10.1037/1040-3590.8.4.369

Lansbergen, M. M., Kenemans, J. L., & van Engeland, H. (2007). Stroop interference and attention-deficit/hyperactivity disorder: A review and meta-analysis. *Neuropsychology*, *21*, 251–262. doi:10.1037/0894-4105.21.2.251

Levin, H. S., & Hanten, G. (2005). Executive functions after traumatic brain injury in children. *Pediatric Neurology*, *33*, 79–93. doi:10.1016/j.pediatrneurol.2005.02.002

Lijffijt, M., Kenemans, J. L., Verbaten, M. N., & van Engeland, H. (2005). A meta-analytic review of stopping performance in attention-deficit/hyperactivity disorder: Deficient inhibitory motor control? *Journal of Abnormal Psychology*, *114*, 216–222. doi:10.1037/0021-843X.114.2.216

Livesey, D., Keen, J., Rouse, J., & White, F. (2006). The relationship between measures of executive function, motor performance and externalising behaviour in 5- and 6-year-old children. *Human Movement Science*, *25*, 50–64. doi:10.1016/j.humov.2005.10.008

Lofthouse, N., Arnold, L. E., Hersch, S., Hurt, E., & DeBeus, R. (2011). A review of neurofeedback treatment for pediatric ADHD. *Journal of Attention Disorders*, *16*, 351–372. doi:10.1177/1087054711427530

Martinussen, R., Hayden, J., Hogg-Johnson, S., & Tannock, R. (2005). A meta-analysis of working memory impairments in children with attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *44*, 377–384. doi:10.1097/01.chi.0000153228.72591.73

McNab, F., Leroux, G., Strand, F., Thorell, L., Bergman, S., & Klingberg, T. (2008). Common and unique components of inhibition and working memory: An fMRI, within-subjects investigation. *Neuropsychologia*, *46*, 2668–2682. doi:10.1016/j.neuropsychologia.2008.04.023

Miller, M. R., Giesbrecht, G. F., Müller, U., McInerney, R. J., & Kerns, K. A. (2012). A latent variable approach to determining the structure of executive function in preschool children. *Journal of Cognition and Development*, *13*, 395–423. doi:10.1080/15248372.2011.585478

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100. doi:10.1006/cogp.1999.0734

Moffit, T. E. (1993). The neuropsychology of conduct disorder. *Development and Psychopathology*, *5*, 135–151. doi:10.1017/S0954579400004302

Morgan, A. B., & Lilienfeld, S. O. (2000). A meta-analytic review of the relation between antisocial behavior and neuropsychological measures of executive function. *Clinical Psychology Review*, *20*, 113–136. doi:10.1016/S0272-7358(98)00096-8

Nee, D., Wager, T., & Jonides, J. (2007). Interference resolution: Insights from a meta-analysis of neuroimaging tasks. *Cognitive, Affective, and Behavioral Neuroscience*, *7*, 1–17. doi:10.3758/CABN.7.1.1

Oosterlaan, J., Logan, G. D., & Sergeant, J. A. (1998). Response inhibition in AD/HD, CD, comorbid AD/HD+CD, anxious, and control children: A meta-analysis of studies with the stop task. *Journal of Child Psychology and Psychiatry*, *39*, 411–425. doi:10.1017/S0021963097002072

Oosterlaan, J., Scheres, A., & Sergeant, J. A. (2005). Which executive functioning deficits are associated with AD/HD, ODD/CD and comorbid AD/HD+ODD/CD? *Journal of Abnormal Child Psychology*, *33*, 69–85. doi:10.1007/s10802-005-0935-y

Pauli-Pott, U., & Becker, K. (2011). Neuropsychological basic deficits in preschoolers at risk for ADHD: A meta-analysis. *Clinical Psychology Review*, *31*, 626–637. doi:10.1016/j.cpr.2011.02.005

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry*, *37*, 51–87. doi:10.1111/j.1469-7610.1996.tb01380.x

Polanczyk, G. V., Willcutt, E. G., Salum, G. A., Kieling, C., & Rohde, L. A. (2014). ADHD prevalence estimates across three decades: An updated systematic review and meta-regression analysis. *International Journal of Epidemiology*, *43*, 434–442. doi:10.1093/ije/dyt261

Poulin, F., Capuano, F., Vitaro, F., Verlaan, P., Brodeur, M., & Giroux, J. (2013). Large-scale dissemination of an evidence-based prevention program for at-risk kindergartners: Lessons learned from an effectiveness trial of the Fluppy Program. In M. Boivin & K. L. Bierman (Eds.), *Promoting school readiness: The implications of developmental research for practice and policy*. (pp. 304–328). New York: Guilford Press.

Raaijmakers, M., Smidts, D., Sergeant, J., Maassen, G., Posthumus, J., van Engeland, H., & Matthys, W. (2008). Executive functions in preschool children with aggressive behavior: Impairments in inhibitory control. *Journal of Abnormal Child Psychology*, *36*, 1097–1107. doi:10.1007/s10802-008-9235-7

Rapport, M. D., Orban, S. A., Kofler, M. J., & Friedman, L. M. (2013). Do programs designed to train working memory, other executive functions, and attention benefit children with ADHD? A meta-analytic review of cognitive, academic, and behavioral outcomes. *Clinical Psychology Review*, *33*, 1237–1252. doi:10.1016/j.cpr.2013.08.005

Rasmussen, C. (2005). Executive functioning and working memory in fetal alcohol spectrum disorder. *Alcoholism: Clinical and Experimental Research*, *29*, 1359–1367. doi:10.1097/01.alc.0000175040.91007.d0

Rubia, K. (2011). "Cool" inferior frontostriatal dysfunction in attention-deficit/hyperactivity disorder versus "hot" ventromedial orbitofrontal-limbic dysfunction in conduct disorder: A review. *Biological Psychiatry*, *69*, 69–87. doi:10.1016/j.biopsych.2010.09.023

Schoemaker, K., Bunte, T., Wiebe, S. A., Espy, K. A., Deković, M., & Matthys, W. (2012). Executive function deficits in preschool children with ADHD and DBD. *Journal of Child Psychology and Psychiatry*, *53*, 111–119. doi:10.1111/j.1469-7610.2011.02468.x

Schoemaker, K., Mulder, H., Deković, M., & Matthys, W. (2013). Executive functions in preschool children with externalizing behavior problems: A meta-analysis. *Journal of abnormal child psychology*, *41*, 457–471. doi:10.1007/s10802-012-9684-x

Schwartz, K., & Verhaeghen, P. (2008). ADHD and Stroop interference from age 9 to age 41 years: A meta-analysis of developmental effects. *Psychological Medicine*, *38*, 1607–1616. doi:10.1017/S003329170700267X

Séguin, J. R. (2004). Neurocognitive elements of antisocial behavior: Relevance of an orbitofrontal cortex account. *Brain and Cognition*, *55*, 185–197. doi:10.1016/S0278-2626(03)00273-2

Séguin, J. R., Boulerice, B., Tremblay, R. E., & Pihl, R. O. (1999). Executive functions and physical aggression after controlling for attention deficit hyperactivity disorder, general memory, and IQ. *Journal of Child Psychology and Psychiatry*, *40*, 1197–1208. doi:10.1017/S0021963099004710

Sergeant, J. A., Geurts, H., & Oosterlaan, J. (2002). How specific is a deficit of executive functioning for attention-deficit/hyperactivity disorder? *Behavioral Brain Research*, *130*, 3–28. doi:10.1016/S0166-4328(01)00430-2

Stevens, S. E., Sonuga-Barke, E. J. S., Kreppner, J. M., Beckett, C., Castle, J., Colvert, E., . . . Rutter, M. (2008). Inattention/overactivity following early severe institutional deprivation: Presentation and associations in early adolescence. *Journal of Abnormal Child Psychology*, *36*, 385–398. doi:10.1007/s10802-007-9185-5

Thorell, L. B., & Wåhlstedt, C. (2006). Executive functioning deficits in relation to symptoms of ADHD and/or ODD in preschool children. *Infant and Child Development*, *15*, 503–518. doi:10.1002/icd.475

Toupin, J., Déry, M., Pauzé, R., Mercier, H., & Fortin, L. (2000). Cognitive and familial contributions to conduct disorder in children. *Journal of Child Psychology and Psychiatry*, *41*, 333–344. doi:10.1111/1469-7610.00617

Tremblay, R. E., Nagin, D. S., Séguin, J. R., Zoccolillo, M., Zelazo, P. D., Boivin, M., . . . Japel, C. (2004). Physical aggression during early childhood: Trajectories and predictors. *Pediatrics*, *114*, e43–e50. doi:10.1542/peds.114.1.e43

Van der Ven, S. H. G., Kroesbergen, E. H., Boom, J., & Leseman, P. P. M. (2013). The structure of executive functions in children: A closer examination of inhibition, shifting, and updating. *British Journal of Developmental Psychology*, *31*, 70–87. doi:10.1111/j.2044-835X.2012.02079.x

Van Mourik, R., Oosterlaan, J., & Sergeant, J. A. (2005). The Stroop revisited: A meta-analysis of interference control in AD/HD. *Journal of Child Psychology and Psychiatry*, *46*, 150–165. doi:10.1111/j.1469-7610.2004.00345.x

Willcut, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention deficit/hyperactivity disorder: A meta-analytic review. *Biological Psychiatry*, *57*, 1336–1346. doi:10.1016/j.biopsych.2005.02.006

Received 14 November 2014; revised version received 19 June 2015