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The impact of instructional context on classroom on-task behavior: A matched comparison of children with ADHD and non-ADHD classmates

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ABSTRACT

Classroom inattentiveness is an important reason for clinical referral of children with ADHD and a strong predictor of their educational achievement. This study investigates classroom on-task behavior of Flemish children with ADHD withdrawn from medication as a function of instructional context. Thirty-one pairs of children (one with ADHD and one age- and sex-matched control; 25 boys and 6 girls 6 to 12 years of age) were observed in their classroom environment during two consecutive school days. On-task behavior (time on-task and on-task span) of ADHD and non-ADHD individuals was compared in different class contexts (i.e., different class structures and academic content types). Individualized teacher supervision was simultaneously assessed. Generalized estimation equation analyses showed that children with ADHD were significantly less on-task than controls during individual work and whole class group teaching, but not during small group work, and had significantly shorter on-task span during academic tasks (mathematics, language, and sciences) and instructional transitions between tasks, but not during music and arts. These effects persisted even after controlling for the higher levels of teacher supervision observed for ADHD pupils (7%) across all contexts (vs. 4% in controls). Findings suggest that despite receiving more overall teacher supervision, children with ADHD displayed lower levels of on-task behavior in settings that place high self-regulatory, information processing, and motivational demands on them. This finding may have initial implications for classroom interventions in this population.

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the most common child psychiatric disorders characterized by deficits in executive function (EF) (Barkley, 1997) and motivation (Sonuga-Barke, 2005). On the behavioral level, these deficits are reflected within age-inappropriate and impairing levels of inattention, hyperactivity, and impulsivity (American Psychiatric Association (APA), 2000). Although these symptoms are considered to be persistent across various contexts, they are also exacerbated in some settings. The school classroom, for instance, has been identified as a primary setting for the expression of problematic behaviors in ADHD (Abikoff et al., 2002; Junod, DuPaul, Jitendra, Volpe, & Cleary, 2006). Pupils with ADHD are often first referred because of difficulty in attending appropriately to educational tasks and exercises (Pelham, Fabiano, & Massetti,

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2005) and failures of academic engagement represent one of the most potent predictors of school achievement and broader patterns of functioning in ADHD (Barkley, Fischer, Smallish, & Fletcher, 2006; Fergusson & Horwood, 1995).

Although deficits in EF (e.g., response inhibition, planning, sequencing, motor control, selective attention) have been shown to predict ADHD-related academic underperformance, it has been suggested that ADHD behaviors, in particular attention, are even a stronger predictor of performance than EF (see review of Daley & Birchwood, 2010). A recent meta-analytic review by Kofler, Rapport, and Alderson (2008) of 23 direct observation studies supported significant classroom inattentiveness in children with ADHD. On average, they were able to focus their attention in classroom settings approximately 75% of the time, compared to 88% for typically developing peers. Although these effects were obtained across a broad range of settings, Kofler et al. highlighted the association between ADHD and high variability in levels of attention to academic tasks, a finding in line with previous reports of interday and intraday variability of ADHD symptoms (Abikoff et al., 2002; Castellanos et al., 2005; Imeraj et al., 2012).

To date, variability in attention to task in ADHD has mainly been investigated by measuring performance during laboratory tasks. Such research mostly focuses on neuropsychological features (e.g., reaction times) and physiological variables (e.g., heart rate variability). These facets appear to be highly context dependent and suggest that on-task behavior needs to be seen as the product of interaction between child characteristics and environmental constraints and demands (Baker, Clark, Maier, & Viger, 2008). Situational factors that reduce attention to task and reduce performance include; the absence of an adult observer (Power, 1992), long task duration (Toplak & Tannock, 2005), lack of rewards (Luman, Oosterlaan, & Sergeant, 2005), and delay (Antrop et al., 2006; Sonuga-Barke, Williams, Hall, & Saxton, 1996). However, it is not sure how deficits in performance and EF seen under strict laboratory conditions present within the situational dynamics of everyday life. Several authors indicate the need to consider children's on-task behavior within the naturalistic classroom environment to fully understand the nature of academic engagement problems and the situational factors that moderate it (Kofler et al., 2008).

The few studies that have systematically assessed the impact of different classroom contexts, settings, and tasks to influence on-task behavior in ADHD (Kofler et al., 2008; Lauth, Heubeck, & Mackowiak, 2006) support the view that on-task behavior in children with and without ADHD is affected by context (Lauth et al., 2006; Whalen, Henker, Collins, Finck, & Dotemoto, 1979). However, findings are inconsistent with regard to specifics. On the one hand, contextual effects that are similar for both groups of children with ADHD and groups of children without ADHD have been described. Some authors reported maladaptive behavior in all children during highly structured activities. For example, Lauth et al. (2006) and Zentall (1980) reported an exacerbation of off-task behavior during whole class teaching (i.e., teacher-initiated structure) as compared to group and individual work conditions (i.e., higher student self-determination/pacing). In contrast, Beck, Kotkin, Swanson, and Miller (1999) identified based on their research results that more structured academic environments can also generate positive effects in classroom behavior (e.g., higher compliance with tasks), whereas Lauth et al. (2006) and Zentall (1980) found that self-paced activities yield both more on-task and out-of-seat behavior. On the other hand, differential effects of context on children with and without ADHD have been observed. Jacob, Oleary, and Rosenblad (1978) reported more daydreaming in children with ADHD in a formal setting but not in an informal setting as compared to controls. Similarly, higher on-task behavior was found in children with ADHD (Hart, Massetti, Fabiano, Pariseau, & Pelham, 2011) and those at risk for disruptive disorders (Baker et al., 2008) during cooperative learning in small class groups as compared to individual work and whole class group teaching.

One explanation for the reported inconsistencies across researchers may relate to the presence of concurrent teacher supervision. For example, small group settings may have beneficial effects as they combine the presence of high levels of structure as well as the opportunity for one-to-one teacher supervision (Baker et al., 2008). Although individual supervision is also more likely during individual work, the latter may place higher self-regulatory demands on the child with ADHD, which may be especially challenging for them. In this sense teachers seem to play an important role in adjusting the classroom environment to the specific needs of the child at risk for learning problems and to encourage classroom attention in different instructional settings (Baker, 2006; Baker et al., 2008). Despite well-known benefits of one-to-one supervision in general on vigilance of children with ADHD (Power, 1992), studies have not, to date, assessed individual teacher supervision across instructional settings in this population. Another possible explanation for this inconsistency is the limited number of settings in which children were observed in previous studies. Most studies focused on academic tasks (i.e., mathematics and language; Lauth et al., 2006), excluding less academically oriented class activities (i.e., music and arts) as well as instructional transition periods between lessons. Attention levels across these different lesson types are, however, likely to be influenced by degree of motivation and levels of difficulty and academic underperformance (Whalen et al., 1978).

Finally, studies have some methodological limitations that may account for discrepancies in results. For example, most studies observed children's behavior during short periods within one day and so their observations may lack reliability and generalizability, in particular because they were unable to control for the confounding type of different instructional settings (Kofler et al., 2008). In addition, studies have rarely employed a level of detail in their observation that would allow the assessment of the duration of each on-task episode. We know of only one study that has investigated classroom attention on a more microscopic level in children with ADHD in a normal classroom setting (Rapport, Kofler, Alderson, Timko, & DuPaul, 2009). The authors found that the children with ADHD remained attentive for shorter durations and switched states more frequently relative to typically developing children. Based on this study, it was not clear whether different instructional effects within the classroom context would influence the expression of such problems.

The aim of this study was to investigate the impact of instructional context on levels of attention-related behaviors among children with ADHD and their normal developing classmates. To address the limitations in previous studies, we included a wider variety of class context conditions (i.e., different class structures and academic content types with inclusion of instructional transition periods) and a range of levels of teacher supervision. Confounding effects of academic performance on on-task behavior

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were additionally explored. From a methodological view, observations were taken across the whole school day on two separate days in order to capture a variety of settings. A more detailed coding allowed the measuring of not only children's overall percentage of time spent on-task but also duration of each on-task interval (i.e., on-task span). We formulated the following research questions:

1. Are attention-related problems in the classroom (as measured by time on-task and on-task span) exacerbated in children with ADHD in specific class context conditions with respect to (a) specific class structures and (b) academic content area with inclusion of instructional transition periods? Our predictions were that children with ADHD will generally display lower levels of on-task and shorter on-task span and that whole class group teaching, highly academic lessons, and transition periods will challenge on-task behavior in all children, but particularly in those with ADHD. In statistical terms, we predicted a significant interaction between group and context conditions. Additionally, we took into account the possible confounding effects of frequently co-occurring problems associated with oppositional defiant disorder (ODD) and academic underperformance in the ADHD group.
2. Does the teacher's supervision levels influence the relation between class context and on-task behavior? Based on our review of literature, we expected that teachers may adapt their levels of supervision to class context and children's specific needs in order to enhance children's attention. These adaptations will influence the interaction between context and group as described in the first research question. To better understand the basis of this relation, we investigated whether (a) class context conditions have an impact on the amount of individual teacher supervision in children with and without ADHD and (b) irrespective of context, whether levels of teacher supervision are related to on-task behavior in both groups. We assumed that, in general, one-to-one teacher supervision will be more common in the individual and small group conditions compared to the whole class group condition and that these teacher practices may particularly affect students with ADHD. We also hypothesized that higher levels of teacher supervision will be associated with more on-task behavior, but this effect may be different in children with and without ADHD.

2. Method

2.1. Participants

Thirty-one children diagnosed with ADHD (25 boys and 6 girls), aged 6 to 12 years ($M = 8.94$, $SD = 1.52$), were recruited from a local child psychiatric outpatient unit in Flanders, Belgium. Each had a formal diagnosis of ADHD (APA, 2000) obtained by a clinical child psychiatric assessment. A multidisciplinary approach was employed including a parental history of child's symptoms as well as information from teachers (and if necessary a school observation), a neuropsychological evaluation, and a medical assessment. Prior to participation, a structured interview for parents (Diagnostic Interview Schedule for Children, parent version, PDISC-IV, Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000) was used to confirm the clinical diagnosis of ADHD Combined Type. Only children with ADHD combined type were included to increase homogeneity of the sample. Participants in the ADHD group were excluded if they had an IQ less than 80 (Wechsler, 1991), a diagnosis of pervasive developmental disorder (APA, 2000), a neurological disorder such as epilepsy or another chronic medical condition; or if they were on nonstimulant or other psychotropic medication (e.g., for anxiety or depression), except for methylphenidate. Twenty-six children with ADHD were taking methylphenidate (17 immediate-release and 9 extended-release formulations), but all children were free from treatment at least 24 h prior to participation in the study so that ADHD behavior could be observed under nonmedicated conditions. Although a longer withdrawal period would be preferable to exclude the risk of rebound effects, this option was not possible due to practical and ethical issues. We assume that a "wear-off" period of 24 h is justified given the short-acting nature of stimulants and the relatively low risk of rebound effects after this period (Carlson & Kelly, 2003). Medication withdrawal was verified with the parents and teacher on the first observation day.

Control participants were 31 age- and sex-matched healthy, normally developing children from the same class as the child with ADHD. These children had not been identified with a medical condition, were receiving no interventions, and were not attending special education classes. All children attended a Flemish regular elementary school. All children were Caucasian. Socio-economic status did not differ significantly between children with and without ADHD. There was no significant difference in terms of highest achieved educational level achieved by mothers, $\chi^2(2) = 1.07$, $p > .05$.

In both groups, the Disruptive Behavior Disorder Rating Scale (DBDRS; Oosterlaan et al., 2008; Pelham, Gnagy, Greenslade, & Milich, 1992) was used to screen for the current presence of not only ADHD symptoms but also other disruptive behavior disorder symptoms, including ODD problems that may contribute to variations in classroom attention levels (Abikoff et al., 2002). This questionnaire was filled out by teachers on the first observation day. This questionnaire contains 42 items rated on a four-point Likert scale from 0 (*not at all*) to 3 (*very much*) yielding four behavior scales: Inattention (9 items), hyperactivity and impulsivity (9 items), ODD problems (8 items), and conduct disorder (CD) problems (16 items). Reliability and validity evidence supporting these four scales for the Dutch translation of the DBDRS appears to be adequate. For example, these scales have evidenced good to excellent internal consistency reliability (Cronbach's alpha range = .88–.94) for both Dutch and Flemish children aged 6 to 12 (Oosterlaan et al., 2008). In our study, children with ADHD were rated significantly higher than their normally developing classmates on all subscales of the DBDRS by teachers. Children with ADHD showed significantly more inattention than the matched controls ($M = 12.48$, $SD = 5.95$ vs. $M = 2.26$, $SD = 3.08$; $p < .001$; Cohen's $d = 2.16$), more hyperactivity and impulsivity ($M =$

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11.00, $SD = 6.48$ vs. $M = 1.65$, $SD = 2.20$; $p < .001$; $d = 1.93$), more ODD problems ($M = 4.71$, $SD = 4.35$ vs. $M = 0.55$, $SD = 1.39$; $p < .001$; $d = 0.91$), and more CD problems ($M = 1.55$, $SD = 2.22$ vs. $M = 0.10$, $SD = 0.30$; $p = .001$; $d = 0.92$).

Additionally, we asked the teachers to rate performance of children of both groups in relation to different lesson contents (mathematics, language, sciences, music and arts) as attention levels across these different lesson types are likely to be influenced by degree of academic underperformance (Whalen et al., 1978). On the first observation day, teachers rated students' performance on a scale from 1 (*insufficient*) to 5 (*well to very well*). In our study, children with ADHD performed significantly worse on mathematics ($M = 3.43$, $SD = 1.23$ vs. $M = 4.30$, $SD = 0.79$; $p = .002$; $d = .84$), language ($M = 3.33$, $SD = 1.04$ vs. $M = 4.20$, $SD = 0.85$; $p = .001$; $d = 0.92$), and sciences ($M = 3.46$, $SD = 1.17$ vs. $M = 4.44$, $SD = 0.70$; $p < .001$; $d = 1.02$), but not worse on music and arts ($M = 3.55$, $SD = 1.13$ vs. $M = 3.85$, $SD = 0.80$; $p = .45$; $d = 0.31$). To control for possible confounding effects of academic underperformance in the ADHD group, we calculated an averaged academic performance score (i.e., the average score on mathematics, language, and sciences).

2.2. Direct observation

Despite the fact that observational research is time consuming, labor intensive, and therefore has a high financial cost, direct observation of children with ADHD in their daily environment is recommended for a number of reasons (Antrop, Buysse, Roeyers, & Van Oost, 2005): (a) laboratory findings are seldom representative for the home and school contexts (Antrop, Roeyers, Van Oost, & Buysse, 2000; Danforth, Barkley, & Stokes, 1991; Tryon, 1993; Zentall & Zentall, 1976), (b) behavior is more variable when observed during children's daily activities (Tryon, Pinto, & Morrison, 1991), and (c) ADHD behavior is particularly expressed within a familiar environment rather than in situations that provoke novelty or fear (Teicher, Ito, Glod, & Barber, 1996; Zentall, 1975). Measuring and quantifying behavior can allow us to reliably estimate and compare across children and settings and to determine the extent to which other factors influence it (Kofler et al., 2008). However, the generalizability of systematic direct observations across time and setting has been thoroughly discussed. For example, Hintze and Matthews (2004) concluded in their study that adequate reliability could not be achieved with respect to on-task/off-task behavior after observing students twice a day (15 min using 60-s interval) over a course of two weeks. These authors make the following suggestions: (a) fewer observations of longer duration should produce more reliable estimations of behavior; (b) observing in more settings might capture a more accurate representation of behavior; and (c) on-task/off-task behavior might be a more complex construct requiring definitions and coding intervals that can capture the nature of behavior in all its complexity. For this study, we therefore chose to (a) observe behavior during longer time periods (four time blocks covering a whole school day) across two consecutive days; (b) consider a wide variety of task-related conditions within the classroom; and (c) assess on-task/off-task behavior continuously, which allows analyses on a more microscopic level (i.e., the duration of each on-task interval). These observation methods are more thoroughly discussed below.

2.2.1. Observational coding scheme

This study is part of a broader research project investigating the influence of contextual factors on ADHD symptoms. In another study, we pointed to the differential susceptibility of ADHD children to classroom idle time by assessing disruptive behavior levels (hyperactivity, noisiness, social disruptive behavior) during idle time and non-idle time periods (Imeraj et al., in press). Although several standardized observation coding schemes are currently available (for a review, see Volpe, DiPerna, Hintze, & Shapiro, 2005), none contains information regarding the various factors that potentially influence classroom behaviors. Our coding scheme (i.e., the Ghent University Classroom Coding Inventory; GUCCI) was developed specifically for this study. This inventory is partly adapted from previously published coding schemes (Abikoff, Gittelman, & Klein, 1980; Blatchford, Bassett, & Brown, 2005; Lauth et al., 2006; Milich & Landau, 1988; Porrino et al., 1983; Tsujii et al., 2007). A more detailed description of the GUCCI codings can be obtained from the corresponding author. For the purpose of this paper, we investigated on-task behavior to educational tasks and activities in ADHD as a function of instructional context. Therefore, we considered three types of class structures and four academic content types during which continuous codings were made for child's on-task behavior and teacher's supervision of the child.

2.2.2. Coding procedure

For coding, two morning and two afternoon blocks across two days were selected to cover a whole school day across both of the two days and to capture a large variety of contextual conditions. More specifically, the four observation blocks were selected such that interday and intraday effects were taken into account. On one day, the first part of the day (including the start of the day to playtime during morning) and the last part of the day (including playtime during afternoon to end of the day) were coded, and on the other day, the second part of the day (including playtime during morning to lunch) and the third part of the day (including lunch to playtime during afternoon) were coded. The mean observation time was 4:34 h ($SD = 36:29$ min). Although observation time differed between schools, observation times for the members of each dyad were similar because the child with ADHD and the matched control were observed simultaneously under the same environmental conditions.

2.2.3. Observer software

Class context categories, child's on-task behavior, and teacher supervision were continuously coded in Observer (Noldus Information Technology, 2009). Video material was imported in this professional software for the coding and analysis of observations. Observer has the advantage that it can select each specific contextual condition to analyze the duration of child's

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on-task behavior (% of time on-task) and the individual teacher supervision received during these periods. The fine grained nature of the coding (i.e., continuous coding without considering fixed intervals for coding) allowed us to additionally analyze more microscopic processes, such as the length of each individual on-task interval (i.e., on-task span, which is on its turn inversely related to the number of shifts between on-task and off-task behaviors).

2.2.4. Class context variables

We assessed three types of class structure and four academic content types that serve as independent variables in our study. The types of class structure included (a) whole group work (e.g., the teacher gives instructions to or teaches the whole class group), (b) small (less than six students) group work (e.g., children are instructed to work in small cooperative learning groups of less than six students), and (c) individual work (students work individually without ongoing whole group teacher instructions; e.g., individual reading and completing worksheets). The academic content types included (a) highly academic lessons (e.g., mathematics and language), (b) academic lessons (e.g., sciences) considered less academic than mathematics and language given the generally more attractive content (e.g., by the use of audiovisual material), (c) nonacademic lessons (e.g., music and arts), and (d) instructional transitions. Instructional transitions reflected class periods just before or after playtime and periods between two different lessons; they were periods of preparation and "winding up" of lessons (e.g., put away a book) and are mostly a combination of instructions (e.g., listening to teacher instruction, carrying out the task, and waiting for the next instruction or start of the lesson). The coding categories for class structure and academic content overlapped, but conditions within each category were mutually exclusive. Contextual codings for the children with ADHD and matched controls were carried simultaneously.

2.2.5. Child behavioral variables

Children's attention-related behavior was continuously coded as on-task vs. off-task, and it served as dependent variables in our study. On-task behavior was scored when children were involved in those class activities "expected" by the teacher. We assumed that children were listening to the teacher when they were doing an assignment or task given by the teacher and when they followed teacher's instructions and requests. Consistent with existing direct observation studies, the current study based the scoring of on-task behavior on whether visual attention to required stimuli was present. Off-task behavior was operationalized as being involved in activities "not expected" by the teacher. Students' off-task behaviors were coded when students were not working on assignments and tasks given by the teacher or not following teacher requests and directives (e.g., daydreaming). However, when the child was engaged in an alternative task-appropriate behavior allowed by the teacher (e.g., sharpening a pencil), the child was considered to be on-task. For further analyses, with the Observer software, we calculated (a) the proportion of time spent on-task during each contextual condition (i.e., on-task duration divided by the total duration of the interval considered) and (b) the mean on-task interval duration (i.e., on-task span, which is the sum of all individual on-task durations divided by the number of times on-task occurs during the interval considered).

2.2.6. Teacher supervision

Codings were made for individual teacher supervision of the child (absent vs. present), and this variable served as both an independent and a dependent variable in our study. Teacher's supervision was coded as present when children were individually interacting with the teacher (e.g., when the child was communicating with the teacher or receiving one-to-one supervision or feedback). When the child was part of the group as a whole (e.g. the child was listening to the teacher without a "one-to-one interaction"), individual teacher supervision was considered to be absent. When teacher supervision served as the dependent variable in further analyses, we calculated the proportion of time the child received individual teacher supervision during each contextual condition. When teacher supervision served as an independent variable in further analyses, we calculated the proportion of individual teacher supervision during the observation as a whole.

2.2.7. Interobserver agreement

Five undergraduate psychology and medical students were intensively trained to work with Observer and supervised by the main researcher to code class structure and academic content type (one student), child on-task behavior (two students), and teacher supervision (two students). Observers were blind to children's diagnostic standing. Interobserver agreement between the students and the main researcher was calculated (i.e., Cohen's kappa for nominal variables). Based on guidelines for evaluation of interobserver agreement presented in Hintze and Matthews (2004), agreement was excellent for class structure ($k = .99$), academic content type ($k = .95$), and teacher's supervision ($k = .99$ to 1.00), and very good for child on-task behavior ($k = .77$ to .84).

2.3. Procedure

This study was approved by the Ethical Committee of Ghent University Hospital, Belgium. Parents of children with ADHD provided written consent and the teacher of the child with ADHD agreed to collaborate in the study. Teachers ($n = 31$) were aware that this study investigated differential effects of classroom contextual factors on behavior in children with and without ADHD. They were, however, blind to the specific factors assessed (e.g., they did not know that individual teacher supervision was being assessed) and specific hypotheses of the study. Teachers selected three sex- and age-matched, normally developing classmates for each ADHD subject; they were asked to not pick their most talented or best-behaved children but those performing and behaving in an average way. If all parents who were approached provided written consent, one child in the control group was

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selected randomly to participate in the study (31 control children were picked from a total of 65 who had consent forms). Prior to the observation days, teachers checked that the child with ADHD and the control child did not sit next to each other to minimize the chance of influencing each other's behavior. Thirty-one paired (ADHD and control classmate) observations were carried out in 31 different classrooms over two consecutive school days in order to capture different instructional context conditions. During the observation, teachers were not required to introduce specific changes to classroom activity (e.g., with respect to schedules) to minimally interfere with the normal class procedures. The observer was introduced to the children as a trainee teacher and was seated in the back of the classroom to serve the cameras during each observation. A camera was positioned in each corner at the front of the classroom to videotape the classroom environment, inclusive of the behavior of the child with ADHD and the control classmate. The children were told that these cameras helped the trainee teacher to remember class activities. On the end of the second day, the real aims of the study were revealed to the children.

2.4. Statistical analyses

To investigate the impact of ADHD and class context on children's on-task behavior, generalized estimation equation (GEE) models with an exchangeable working correlation matrix were used. GEE is an appropriate technique to take account of the correlations among repeated observations of the same participant without the covariance structure being of central interest (Zeger & Liang, 1986). The most popular form of inference on GEE regression parameters is the Wald Chi-square test. As the dependent variables, we used two continuous scores: (a) the proportion of time on-task and (b) the duration of each on-task interval (i.e., on-task span). In a first set of analyses, predictors were class structure (whole group vs. small group vs. individual work), group (ADHD vs. control), and the group x class context condition interaction term. The standardized mean difference between groups (i.e., Cohen's $d = (M_1 - M_2)$ divided by the SD_{pooled}) was additionally calculated and defined as *small* (0.2), *moderate* (0.5), and *large* (0.8) effect sizes. Although effect size is not strictly speaking the same thing as clinical significance, we assume that they will be strongly correlated. In contrast to statistical power, the effect size is independent of sample size and varies with precision of measurement (Swanson et al., 2001). Precision in this study was increased by averaging observation data across four time blocks. In a second set of analyses, the analyses above were repeated with academic content (highly academic vs. academic vs. nonacademic vs. instructional transitions) as the context condition. In these two sets of analyses, we additionally controlled for ODD problems and averaged academic performance as these variables may also contribute to variations in classroom on-task behavior.

To investigate whether the impact of ADHD and class context on on-task behavior is related to levels of teacher supervision, the two main sets of analyses were repeated with additional inclusion of teacher supervision as a covariate. To better understand this relation, we explored (a) the impact of ADHD and class context on teacher supervision by repeating the main analyses with teacher supervision as the dependent variable and (b) the effect of teacher supervision and ADHD on on-task behavior by doing analyses with on-task variables as the dependent variables and group, teacher supervision, and the interaction term as the predictors. All analyses were performed in SPSS (version 19). An alpha of .05 was used for all tests of significance.

3. Results

3.1. Class context characteristics

We assessed three types of class structure and four academic content types. With respect to class structure, on average, the children with ADHD and the matched controls as a whole spent 59% ($SD = 26\%$) of their time on whole group work, 6% ($SD = 15\%$) of their time on small group work, and 35% ($SD = 27\%$) of their time on individual work. With respect to academic content type, children spent 42% ($SD = 29\%$) of their time on highly academic tasks, 19% ($SD = 30\%$) of their time on less academic tasks, 25% ($SD = 23\%$) of their time on nonacademic tasks, and 14% ($SD = 9\%$) of their time on instructional transitions between lessons.

Table 1
Wald statistics of GEE analyses for group and class structure/academic content type with respect to on-task behavior variables: basic analyses and analyses controlling for teacher supervision.

	Basic analyses			Analyses controlling for teacher supervision			
On-task behavior variables	Group[a]	Context[b,c]	Group x context	Group[a]	Context[b,c]	Group x context	Supervision
In the class structure model[b]							
Time on-task	12.23*	18.36*	6.87*	16.91*	18.93*	9.13*	2.81
On-task span	4.04*	1.90	0.42	4.75*	1.77	0.43	2.29
In the academic content model[c]							
Time on-task	22.82*	12.26*	0.21	29.02*	12.39*	0.22	0.99
On-task span	19.37*	34.30*	8.18*	25.01*	33.89*	8.29*	0.95

Note.
[a] For the group variable, children with ADHD and control children were compared.
[b] For the class structure variable, whole class group, small class group, and individual work were compared.
[c] For the academic content variable, highly academic tasks, less academic tasks, nonacademic tasks, and instructional transition periods were compared.
* $p < .05$.

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3.2. Effect of class context on classroom on-task behavior in ADHD and non-ADHD pupils

3.2.1. Class structure and classroom on-task behavior

As shown at the top left panel of Table 1, GEE analyses revealed a main effect of group: Children with ADHD displayed statistically significantly less time on-task ($p < .001$) and shorter on-task span ($p = .04$) than controls. With respect to on-task behavior, there was a main effect of class structure, with greater time on-task during small group work compared to individual work ($p < .001$). There was also a significant interaction between ADHD group and class structure for time on-task, $p = .03$, with post-hoc paired comparisons showing that children with ADHD were significantly less on-task than controls during individual work, $M_{diff} = 8\%$; 95% CI [2, 14]; $p = .007$, and whole class group teaching, $M_{diff} = 10\%$; 95% CI [6, 15]; $p < .001$, but not during small group work, $M_{diff} = 2\%$; 95% CI [−3, 8]; $p = .39$. Although the interaction effect was not statistically significant for on-task span, this finding may be due to a lack of power with the sample size included. The top panels in Fig. 1 show mean values of and effect sizes for on-task variables as a function of group and class structures. Thus, the smaller effect size between groups during small group work as compared to whole group work and individual work suggests that similar effects for on-task span (top right side) as those for time on-task (top left side) may be present.

3.2.2. Academic content and classroom on-task behavior

As shown at the bottom left panel of Table 1, there was a main effect of academic content type with significantly higher on-task levels during music and art lessons compared with science lessons, mathematics and language, and instructional transitions for both the ADHD and the control groups ($p = .007$). Statistically significantly longer on-task span was noted during both mathematics and language as well as sciences as compared to transitions ($p < .001$). The interaction between ADHD group and academic content was statistically significant for on-task span, $p = .04$, with post hoc paired comparisons showing that the ADHD group had significantly shorter on-task span than controls during mathematics and language lessons, $M_{diff} = 102$ s; 95% CI [57, 148]; $p < .001$, sciences, $M_{diff} = 112$ s; 95% CI [49, 175]; $p = .001$, and transitions, $M_{diff} = 68$ s; 95% CI [37, 98]; $p < .001$, but not during music and arts, $M_{diff} = 27$ s; 95% CI [−27, 81]; $p = .33$. Although the interaction effect was not statistically significant for time on-task, this finding may be due to a lack of power. The bottom panels of Fig. 1 show mean values of on-task variables and effect sizes as a function of group and lesson content. Given the larger effect sizes in the more academic settings as compared to the nonacademic setting, results suggest that similar effects for time on-task (bottom left side) as those for on-task span (bottom right side) may be present.

3.2.3. Influence of ODD problems and academic performance

As noted at the end of the Participants section, teachers reported more ODD problems and more academic problems in children with ADHD than the controls. The ODD problem score was correlated with on-task span (Wald $\chi^2 = 5.83$; $p = .02$; $\beta = -2$ s). Also the averaged performance score was correlated with time on-task (Wald $\chi^2 = 8.96$; $p = .003$; $\beta = 4\%$) and

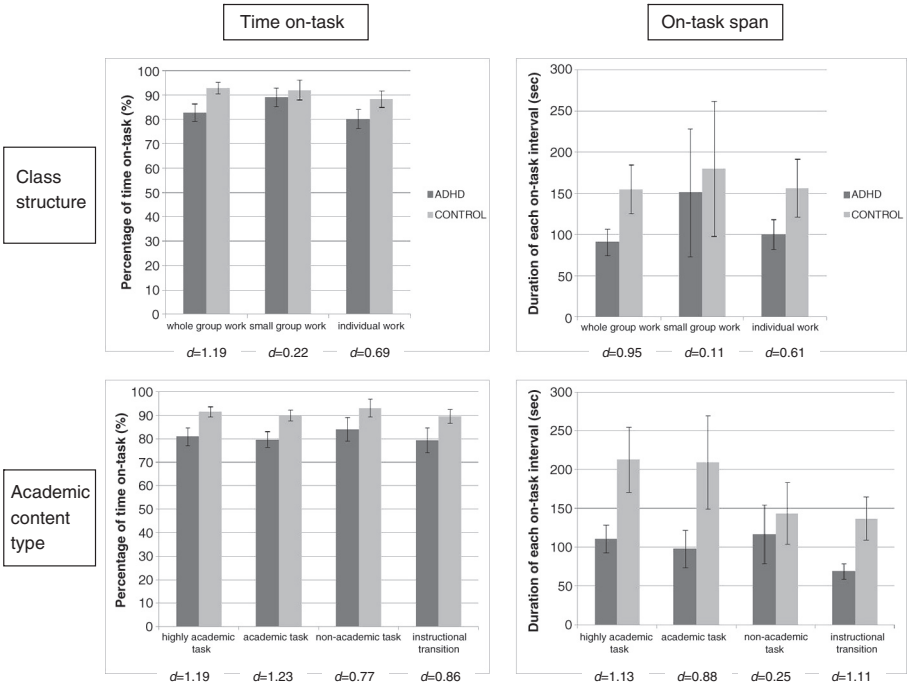

Fig. 1. Group differences (ADHD vs control) in mean values (with 95% CI) of time on-task (left) and on-task span (right) across different class structures (top) and academic content types (bottom). Standardized group differences in each class condition are presented as Cohen's *d*.

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on-task span (Wald $\chi^2 = 5.86$; $p = .02$; $\beta = 14$ s). When the ODD problem scores and the averaged performance scores were included separately as a covariate in the models described above, ODD problems and academic performance no longer contributed to variations in on-task variables and did not alter the relations presented in Table 1.

3.3. Effects of teacher supervision on the relation between context and on-task behavior in ADHD and non-ADHD pupils

As the teacher may play an important role in adapting environmental demands to the child's specific needs, individual levels of teacher supervision may influence the relation between context and on-task behavior in children with and without ADHD. To better understand the basis of this relation, we investigated (a) whether the amount of teacher supervision varied as a function of group and class context and (b) whether the level of teacher supervision contributed to variations in on-task behavior. Finally, the amount of supervision was included as a covariate in the basic analyses presented in the left panels of Table 1 to investigate whether teacher supervision alters these findings. The analyses controlling for teacher supervision are presented in the right panels of Table 1.

3.3.1. Effect of class context and group on teacher supervision

There was a statistically significant main effect of group on levels of teacher supervision (Wald $\chi^2 = 5.81$; $p = .02$ in the model with class group structure; and Wald $\chi^2 = 17.56$; $p < .001$ in the model with academic content). Children with ADHD received significantly more individual teacher guidance than their control classmates across all settings ($M = 7\%$, $SE = 0.7\%$ vs. $M = 4\%$, $SE = 0.9\%$). There was also a statistically significant main effect of class structure (Wald $\chi^2 = 21.57$; $p < .001$). Teacher supervision was significantly greater during small group work compared to whole class group teaching ($M = 8\%$, $SE = 2\%$ vs. $M = 4\%$, $SE = 0.3\%$). There was also a statistically significant main effect of academic content (Wald $\chi^2 = 37.26$; $p = .001$): Teacher supervision was significantly higher during mathematics and language lessons than during music and art lessons ($M = 5\%$, $SE = 0.4\%$ vs. $M = 3\%$, $SE = 0.5\%$). With respect to transition periods, teacher supervision was lower as compared to mathematics and language ($M = 3\%$, $SE = 0.2\%$ vs. $M = 5\%$, $SE = 0.4\%$) and sciences ($M = 3\%$, $SE = 0.2\%$ vs. $M = 5\%$, $SE = 0.6\%$). The interaction effects of group and class structure (Wald $\chi^2 = 2.67$; $p = .26$) and group and academic content type (Wald $\chi^2 = 3.41$; $p = .33$) were not significant.

3.3.2. Effect of teacher supervision on classroom on-task behavior

Higher supervision levels significantly predicted longer on-task span (Wald $\chi^2 = 8.73$; $p = .003$) but not higher levels of time on-task (Wald $\chi^2 = 0.21$; $p = .65$). These relations were similar for the children with ADHD and the control group as the interaction between teacher supervision and group was not statistically significant for on-task level (Wald $\chi^2 = 0.14$; $p = .71$) and on-task span (Wald $\chi^2 = 2.95$; $p = .10$).

3.3.3. The effect of teacher supervision on the relation between context x group and on-task behavior

We investigated the impact of group and class context on classroom on-task behavior when the overall amount of individual teacher supervision was controlled. As shown in the right panels of Table 1, teacher supervision no longer contributed to on-task behavior when included in these models, and it did not alter main findings (presented in the left panels of Table 1) with regard to the impact of ADHD group by class context conditions.

4. Discussion

This study investigated the influence of different instructional contexts on classroom on-task behavior among children with ADHD withdrawn from medication and their typically developing classmates within their naturalistic classroom environment. Firstly, effects of different class structures and academic content types on on-task behavior (operationalized as percentage of time on-task and on-task span) in ADHD and non-ADHD groups were investigated. Secondly, the impact of concurrent level individual teacher supervision across these conditions was examined and its effects on on-task behaviors were explored.

Related to the first research aim, this study supported a differential influence of class context on on-task behavior in children with and without ADHD. This despite the fact that children with ADHD overall showed less time on-task as compared to controls and the fact that instructional conditions have an impact on attention-related behavior in all children. The finding that children with ADHD generally displayed lower on-task levels compared to their peers (*overall mean difference* = 10%; $d = 0.61$) is consistent with previous results in naturalistic classroom environments (Abikoff et al., 2002; Junod et al., 2006; Lauth et al., 2006; see also the meta-analysis of Kofler et al., 2008). The classroom is a context with high educational demands in which self-regulatory (Barkley, 1997) and motivational (Sonuga-Barke, 2005) problems could exacerbate off-task behavior in children with ADHD. These differences are educationally relevant as classroom inattention problems in elementary school-age children are often a reason for clinical referral and predict scholastic underachievement later in life (Kofler et al., 2008; Pelham et al., 2005; Rapport, Scanlan, & Denney, 1999). In line with Rapport et al. (2009), we also found shorter on-task span (and relatedly, more on-task shifts) in children with ADHD. The authors suggested that such attention processing deficits are consistent with theoretical models of ADHD predicting attentional resource problems (Sergeant, 2000) and working memory deficits (Rapport et al., 2008). As expected, lower levels of on-task behavior were related to ODD problems and academic underperformance, which were obviously more present in the ADHD sample. However, in more expanded models including diagnostic group (ADHD vs. control) as a factor, these relations were no longer statistically significant, suggesting that on-task behavior problems may be specific to ADHD as such rather than a nonspecific effect of comorbid conditions. In their model of dual developmental pathways,

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Rapport et al. (1999) found previously that disruptive behavior problems are unrelated to academic underachievement later in life, except by their common relation with attention deficits. Alternatively, it may be that methodological issues may account for some of these differences. Whereas our variables of interest (on-task behaviors) were directly observed by the investigators, ratings for ODD problems and academic performance were based on teacher's evaluations on the first observation day, possibly including a perception bias or referring to a different time frame. Here we have no long-term outcome data on children's academic achievement.

In both groups, on-task behavior varied as a function of instructional settings: There was a beneficial effect of small group work in terms of on-task levels as compared to individual work. This finding is likely to be due to the fact that small group work provides high levels of structure, more active roles for children, and high opportunities for individual teacher feedback (Baker et al., 2008; Downer, Rimm-Kaufman, & Pianta, 2007). Although whole group teaching is associated with a high level of teacher-initiated structure, it provides only little opportunities for individual teacher–child interactions, whereas the opposite is considered to be true for individual work (Baker et al., 2008). Our results differ however from those in other studies that reported higher off-task behavior during teacher-initiated class activities (whole class group teaching) versus choice of self-pacing and determination (individual and small group work; Lauth et al., 2006; Zentall, 1980). This discrepancy with respect to individual work could be due to different operationalizations of categories across studies. In our study, children could sometimes choose to complete an individual assignment, but most of the time they could not choose their specific activity. Individual work included, for example, highly academic exercises for which high self-regulatory and motivational skills are needed to complete such tasks. We also found that on-task behavior varied as a function of academic content of sessions. In all children, nonacademic tasks (i.e., music and arts lessons) were associated with higher time on-task as compared to other academic content categories (i.e., mathematics and language, sciences, and instructional transition periods). During academic lessons, on-task span was longer as compared to transition periods. It may simply be the case that the task demands of transitions call for more switches between tasks or create more wait states in which an operationally defined break in attention is just complying with task demands. Alternatively, this finding could be due to the fact that, during these academic tasks (mathematics and language) but not during transitions, teachers' supervision was more intense compared to nonacademic ones (music and arts) in an attempt to encourage on-task behavior during high demanding tasks; even during those tasks, quantity of the teacher child interactions was however limited.

Most importantly, however, we found a differential influence of context on children with ADHD, which could not be explained by the presence of comorbid ODD problems or academic underperformance. Although children with ADHD overall showed less time on-task as compared to controls, this effect was due to group differences during individual work and whole class group teaching but not during small group work. Although small group work yielded the highest levels of on-task focus in all children, it seems that children with ADHD benefit especially from this specific class group structure even where no additional supervision is given. During small group work, cooperative learning by interaction with peers is considered to be greater than in other settings. Although each of the group structures considered potentially plays a vital role in the learning process (Baker et al., 2008), the amount of small group work is limited during the observation period. One implication of the current study would be the promotion of this sort of class setting for ADHD pupils. Academic content was also important in this regard. Even after controlling for academic performance, shorter on-task span in children with ADHD as compared to controls was present during mathematics and language, during sciences, and during instructional transition periods, but not during music and arts. Rapport et al. (2009) suggested that, compared to laboratory tasks, classroom academic tasks typically involve more controlled processing, place greater demands on cognitive resources, including the ability to store and manipulate information in working memory, and require complex strategic mechanisms of self-regulation and planning which can adapt flexibly to changes in the classroom environment. As on-task behavior can be seen by the product of child by environment, this result may reflect the outcome of a unique combination of high educational demands of the environment and typical deficits associated with ADHD to cope with these demands.

Related to the second aim, this study investigated whether the interaction between group and context was modulated by teacher's supervision levels. In line with Greene, Beszterczey, Katzenstein, Park, and Goring (2002) we found that, in general, teachers provided more supervision for children with ADHD compared to their normally developing peers. The presence of an adult supervisor has previously been reported to decrease distractibility in children with ADHD (Power, 1992). In our study, higher teacher supervision was significantly related to better attention (increase of on-task span) in general: these effects were similar for ADHD and controls across settings. Furthermore even when levels of teacher supervision were taken into account children with ADHD showed less attention. This suggests that – while supportive teacher behavior represents a prime target for intervention – ways to improve the impact of teacher supervision, perhaps by increasing the amount of supervision, need to be considered. Given their high needs for encouragement and reward seen in prior studies (Luman, Tripp, & Scheres, 2010; Sonuga-Barke, 2003), future research may investigate whether children with ADHD need a qualitatively different sort of supervisory support to other children (Baker, 2006). Based on the current findings, it is not known if the normal classroom is an ideal setting for pupils with ADHD or whether special educational settings where different teaching approaches are used might be more appropriate.

Despite the fact that children with ADHD showed more problems in on-task behavior during academic tasks, teachers did not further increase their individual supervision during these academic assignments as compared to other tasks to at least partly approach the specific child's needs. Although increased supervision was related to better on-task behavior in both groups as mentioned above, Barkley et al. (2006) reported previously that children with ADHD were less able to benefit from a close teacher relationship. In this study, teacher supervision in children with ADHD (although *overall* higher as compared to control classmates) might still not be sufficient to increase on-task levels during high demanding tasks. As *overall* supervision levels are relatively low during an average school day, we could assume that an additional increase in supervision in children with ADHD only during high demanding tasks (*not overall*) and not during less demanding ones could still have a positive effect. However, such adaptations in teacher behavior may yield practical problems considering the decreasing, albeit still high, number of pupils in today's regular

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classrooms (the average class size in Belgium is 20; see OECD & PISA, 2012). It would be of large interest to explore the impact of different teacher strategies, such as proactive teacher practices (Ervin, DuPaul, Kern, & Friman, 1998), and the use of explicit rules with clear consequences for noncompliance (Emmer & Stough, 2001) on on-task levels in children with ADHD within specific instructional contexts. Next to teacher supervision, other adaptive classroom management approaches should be considered. For example, this study showed that small group work seems to be a good strategy to increase on-task behavior especially in children with ADHD. Additionally, the special structuring of classroom transitions, for example, has been proven to be an effective way of reducing disruption (Lee, 2006).

4.1. Strenghts and limitations

The study had many strengths. To the best of our knowledge, this was the first study to investigate different measures of on-task behavior in children with ADHD and their normal classmates across different instructional contexts; not only class structure and academic content type (inclusive instructional transition periods) were included but also individual teacher supervision levels as teachers are supposed to adapt the environment to the child's needs. To capture a larger variety of settings, we observed children in their naturalistic class environments for a longer period of time (i.e., two consecutive school days) than many previous researchers (see meta-analysis of Kofler et al., 2008).

There were also limitations to this study. First, the naturalistic class environment represents a less-standardized, less-controlled setting as compared to the laboratory context. It was not possible to control for every aspect of stimulation or structure within the environment (e.g., the effect of the camera, the presence of the examiner, additional noise, unexpected interference). As the children with and without ADHD were observed simultaneously in the same classroom, it is reasonable to assume that these effects were similar for both groups. Supplemental analyses supported the two-day observation period as the frequency of teacher supervision was found to be significantly higher on day 1 than on day 2 ($p < .05$). However, these differences across days did not alter the main findings of this study as results were confirmed for day one and day two separately. No differences across days were found for on-task behavior.

Second, despite the ecological nature of our observations, findings may not generalize to all settings and all school days (Hintze & Matthews, 2004). Current findings relate to Flemish regular elementary classrooms and therefore may not be representative for other world parts, special education settings, or home environments. Third, sample size in this study was limited (31 children in each group), and four times more boys than girls were included. Although additional analyses with boys only (25 boys in each group) revealed similar results to those obtained for the whole sample, more subtle sex differences may be present and operate to confound our results. Fourth, we included children with ADHD removed from medication to observe behavior in the absence of any medication effects. On the one hand, this medication withdrawal in children with ADHD may limit generalizability of conclusions to all children with ADHD, particularly when treated with medication. On the other hand, it would be interesting to take into account contextual influences on classroom behavior in future medication effect evaluation studies.

Fifth, teachers may have acted differently during the observation as they knew which children were included in the study. Moreover, a selection bias could be present as teachers were asked to select the control child. However, the control child was randomly selected from a selection of three possible control children that were considered to show an average behavior. Sixth, we considered the average duration of each on-task interval as a measure for on-task span (and relatedly on-task shifts). This measure may, however, not map exactly on the constructs used when investigating attention processing during controlled tasks. On-task behavior was studied as a meaningful construct in itself and not as a proxy for neural functioning (e.g., alerting and orienting processing). Seventh, it is not clear to what extent peer interactions during small group work could have influenced behavior in children with ADHD. As favorable effects of peer tutoring interventions have been described (DuPaul, Ervin, Hook, & McGoey, 1998), it would be interesting to further explore the quality of this close cooperation between pupils.

Eight, baseline rates of teacher supervision in the normal class environment were low overall. Therefore, we assessed only the amount of supervision quantity but not the quality of teacher–child interactions (e.g., positive support vs. negative feedback), which may be interesting to include in future studies. Additionally, the finding of overall higher levels of teacher supervision in the ADHD group restricted generalization of our findings. To fully explore the effect of teachers' practices on on-task behavior in children with and without ADHD within different instructional contexts, a quasi-experimental study in which not only class context conditions but also levels of teacher supervision are similar for both groups would be helpful. A similar approach could also be helpful in teasing out the teacher versus context effects because those effects may be confounded in a way that is not separable in the current study (i.e., some activities naturally lead to more teacher attention). Finally, such a quasi-experimental approach could be used to further investigate specific combinations of class structures and academic content types and their effect on on-task behavior. Although we observed children during a longer time period than previous researchers (see meta-analysis of Kofler et al., 2008), the occurrence of some conditions (especially small group work) was too small in the naturalistic setting to allow additional subdivisions. Additional analyses, however, showed that small group work was present during both nonacademic tasks (30%) and academic tasks (70%). The beneficial effect of small group work on on-task behavior could, therefore, not uniquely be related to the overlap with less demanding nonacademic tasks.

4.2. Conclusion

In sum, this study supported a differential impact of instructional contexts on classroom on-task behavior in children with ADHD withdrawn from their medication as compared to their normal developing classmates. Although children with ADHD were

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overall less on-task than their peers, group differences were particularly clear during whole group teaching, individual work, and instructional transition periods and when they were assigned highly academic tasks. High self-regulation, information processing, and motivational demands within these contexts interact with the specific deficits associated with ADHD. Teachers did provide more supervision to ADHD pupils, but despite this finding, the deficits associated with the disorder seen persisted. Alternative strategies such as small group work may have a stronger impact on classroom on-task behavior than teacher supervision, especially in children with ADHD. Further research to properly understand the dynamics of the class environment is needed to determine effective teacher strategies and to guide academic interventions for increasing attention-related behavior that may lead to better academic performance and long-term outcomes in children with ADHD (Daley & Birchwood, 2010).

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