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Evidence of Poor Planning in Children with Attention Deficits

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This study examined the planning performance of children with attention deficits, and also investigated the possible interactions between inattention and anxiety in the performance of executive function tasks. A group of 98 children (grades 4 and 6), derived from an initial group of 550, were assigned to an attention difficulties group (AD) and a control group ($n = 49$ each) based on their scores on a variety of cognitive attention measures and teacher scales of attention and hyperactivity. The two groups were matched on age, gender, parental education, non-verbal and verbal ability. They were compared on Crack-the-Code (C-t-C) action-planning task, embedded and ambiguous figures and Theory of Mind tasks. Analyses indicated that the failure of AD children on cognitive performance measures is linked to planning impairments. The co-occurrence of anxiety, in turn, did not interact with inattention to affect planning performance differentially. Implications of these findings for the current discussion about the cognitive and emotional processes underlying impaired performance among children with attention deficits on executive control tasks are discussed.

KEY WORDS: attention deficit; planning; theory of mind; anxiety.

Attention deficit hyperactivity disorder (ADHD) is among the best-researched disorders of childhood. Children with this disorder are characterized by high energy levels, poor social skills, poor organization, academic difficulties, lack of concentration, impulsivity and many other difficulties (Campbell, 2000). Accumulating evidence shows that executive functioning (EF) represents the cognitive mechanism that best differentiates children with and without attention deficits (Barkley, 2001; Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001). The fact that executive functioning pervades a wide range of processes such as planning, inhibition, coordination, and self-regulation justifies the quest for the nature of the relation of EF to inattentive behavior, which represents the main goal of the present study. The following sections describe the executive function deficits that are examined, along with the specific tasks used to address them.

Less attention has been paid in the literature to the potential effects of anxiety on impaired executive functioning. Some research with go/no-go tasks has provided initial indications that children with comorbid ADHD and anxiety may outperform their ADHD—only peers possibly due to a buffering effect of anxiety (Pliszka, Borcherding, Spratley, Leon, & Irick, 1997). A preliminary examination of the role of anxiety in the performance of EF tasks by AD children is also reported.

Executive Function and Planning in Attention Deficits

Executive function deficits have been linked explicitly to inattention in recent research. Poor performance by children with ADHD has been found both with relatively complex (e.g., Wisconsin Card Sorting Test, Trail Making, Tower of Hanoi, story retelling, Porteus Mazes, and recently Theory of Mind) and with simpler EF tasks (e.g., Self-Ordered Pointing Test, Controlled Oral Word Association Test, and Rey-Osterrieth Complex Figure) that are sensitive to frontal lobe impairments. These deficiencies

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(Perner, Kain, & Barchfeld, 2002) have been explained as resulting from the inability to sustain an organized, planful approach while simultaneously attempting to avoid responding in an impulsive manner (Aman, Roberts, & Pennington, 1998; Chelune, Ferguson, Koon, & Dickey, 1986), deficiencies in automatic information processing, fewer self-corrections, and the use of less efficient strategies and poorer self-regulation (Berman, Douglas, & Barr, 1999; Shue & Douglas, 1992; Tannock, Purvis, & Schachar, 1993).

Planning and strategy development appear to discriminate well between children with and without attention deficits (Kempton et al., 1999; Naglieri, Goldstein, Iseman, & Schwebach, 2003; Perchet, Revol, Fourneret, Mauguiere, & Garcia-Larrea, 2001). For the purposes of this study, we define planning as a self-organizing reflective activity that integrates information from external and internal sources to create and execute meaningful behavioral responses for the solution of a novel task. The Crack-the-Code (C-t-C) task used in this study (see method section) is designed to examine planning behaviors as defined above. The task uses specific latency measures that can elucidate the cognitive processes involved in planning performance, rather than focusing only on the outcome of performance.

Theory of Mind and Flexibility

In addition to planning, EF has also been found to correlate with performance on Theory of Mind (ToM) tasks in recent research (e.g., Perner et al., 2002). ToM describes the ability to infer mental states such as desires, feelings, and beliefs in oneself and others (Perner & Lang, 1999). The relation between ToM and EF may rely on specific processes of inhibition and working memory capacity (Carlson, Moses, & Breton, 2002). For instance, retention of information in short-term memory is important for answering questions requiring pragmatics and inference, while, simultaneously and accurately retaining several pieces of information in memory. To attain this objective, one must inhibit references to irrelevant information and/or avoid impulsive responding on the basis of the most obvious phenomena (see Appendix). Consequently, one may expect ToM tasks to differentiate ADHD children from controls. Although some support exists for this notion, research findings indicate that ADHD impairment only becomes apparent on second-order ToM tasks, which require extensive use of working memory and high inhibitory control (Buitelaar, van der Wees, Swaab-Barneveld, & van der Gaag, 1999; Carlson & Moses, 2001), but even these conclusions are inconsistent (Charman, Carroll, & Sturge, 2001; Perner et al., 2002). Hence, further research is necessary to establish the relationship between ADHD and performance on ToM tasks. Thus, this study includes both first- and second-order ToM tasks.

Among the flexibility tasks that are related to executive dysfunction, ambiguous and embedded figures appear to hold a paramount position. These tasks have been used to demonstrate EF impairments in a variety of disordered populations (e.g., dyslexics, dysfunctionally impulsive; Brosnan et al., 2002; Brunas-Wagstaff, Bergquist, Morgan, & Wagstaff, 1996). Studies like these have shown that accurate performance on such tests necessitates inhibition of distractors, an ability which is also lacking in children with attention deficits. Despite this potential correlation, embedded and ambiguous figures have been used with children with attention deficits in only a limited set of earlier studies (specifically, only embedded figures have been used in studies by Campbell & Douglas, 1972; Campbell, Douglas, & Morgenstern, 1971; Douglas, 1972). In these studies, embedded figures were found to discriminate children with and without attention deficits, presumably on the basis of less efficient visual scanning skills and the inability to evaluate the correctness of their responses. These deficiencies make these tasks relevant to EF. Probably, for this reason, embedded figures have also been found to load on the same factor with other tests tapping executive control, such as Porteus Mazes and Matching Familiar Figures (Campbell & Douglas, 1972).

Overall, by using a number of different executive control tests that rely on the use of inhibition, planning, and flexibility, the present study attempts to provide explanations for these processing deficiencies and also descriptions of how global these deficiencies may be.

Anxiety and Executive Control

Comorbidity between externalizing and internalizing disorders and the functional consequences of having multiple diagnoses (Hinshaw, Lahey, & Hart, 1993) has been a recent focus of interest in populations with attention deficits. Over half of the children diagnosed with ADHD also meet criteria for another disorder, particularly conduct and oppositional defiant disorder (August, Realmuto, MacDonald, Nugent, & Crosby, 1996; Jensen, Martin, & Cantwell, 1997), but internalizing disorders are also very frequent (Biederman, Newcorn, & Sprich, 1991). In fact, a study by Connor et al. (2003) indicates that early age of onset of ADHD was correlated with increased rates of aggressive symptoms whereas late onset of ADHD was correlated with elevated levels of internalizing symptoms.

The association between anxiety, in particular, and ADHD has been documented multiple times (Barkley, 1998; Fones, Pollack, Susswein, & Otto, 2000).

In the realm of performance, the most consistent finding has been that the comorbid diagnosis of anxiety may lower the adverse effects of impulsivity on tasks such as the CPT (Continuous Performance Test; Epstein, Goldberg, Conners, & March, 1997; Oosterlaan, Logan, & Sergeant, 1998). Manassis, Tannock, and Barbosa (2000) found that children with ADHD+anxiety were more similar to normal and anxiety only children on an RT-stop task, outperforming the ADHD-only group. However, not all studies have found this effect. The MTA Collaborative Group (2001) found significant differences between ADHD and normal controls on various aspects of the CPT, but no significant interaction between ADHD and comorbid disorders, including anxiety.

The picture of improved performance does not seem to hold for other types of tasks that rely less on executive control. Karustis, Power, Rescorla, Eiraldi, and Gallagher (2000) have examined the effect of anxiety, measured using the Revised Children's Manifest Anxiety Scale, on academic and social difficulties of 7–12-year-old children diagnosed with ADHD. They found no significant relations between either anxiety or depression and the academic performance of ADHD children. On complex working memory tasks, comorbid anxiety may actually hinder further the performance of ADHD children, due to worry-related interference (Pliszka, 1989). Similarly, Barkley et al. (2001) found differences between ADHD and control children on inattention and time estimation measures but no significant interactions with comorbid anxiety. In sum, it appears that research to date has only partially supported circumscribed benefits associated with comorbid anxiety on cognitive tasks that are influenced by impulsivity, whereas on other cognitive measures such as memory and academic performance, anxiety may either hinder performance or have no significant interaction with ADHD. This conclusion points to the need for further research to establish the role of anxiety in performance on tasks tapping planning, theory of mind, and flexibility among children with attention difficulties (AD). This is a secondary purpose of this study.

The Purpose of the Present Study

The present study examined the performance of children selected for attention difficulties (AD) and a control group on a number of EF measures. Specifically, the aims of the study were to verify the poor planning performance of children with attention deficits when using a novel computerized task (the C-t-C) and a number of other executive function measures, specifically, Embedded and Ambiguous Figures and Theory of Mind tasks, that have not been previously investigated fully in relation to attention deficits. It is hoped that these novel tasks may permit a more specific analysis of the planning EF processes central to the deficits of AD children.

It has to be mentioned that in the absence of any formal diagnosis of attention deficit hyperactivity disorder (ADHD) the term AD is used throughout this paper describing the participating group as exhibiting mainly attention problems. This means that teachers judged these children to have observable attention problems, which, in turn, were confirmed by the children's scores on attention measures. Thus, in the absence of a formal diagnosis, the children in the present AD group may include cases that could have been diagnosed as ADHD or cases with some subsyndromal ADHD characteristics.

The secondary aim was a preliminary investigation of the role of anxiety in the performance of attention deficit and control groups. Our prediction was that performance of AD children on tasks that require selective attention, inhibition of impulsive behavior, flexibility, and strategic planning might benefit from the co-existence of anxiety as some prior research has documented. Specifically, it was hypothesized that the AD+anxiety children would outperform AD-only children even if they were outperformed by controls (see also the review by Nigg, 2001).

In sum, the significance of this study lies (a) in the inclusion of multiple cognitive tests, (b) in the fact that one of these tests, the C-t-C may be optimal for detecting process differences, by emphasizing varying strategic styles of approaching the task, and (c) in the attempt to specify the possible interactions between planning performance, inattention, and anxiety. In addition, the study used a carefully controlled methodology for selecting participants, addressing in this way the concerns that have been raised in the literature regarding previous studies of AD and AD+anxiety (Nigg, 2001).

METHOD

Participants

The initial sample consisted of 550 children from 12 schools, randomly chosen, among those that traditionally collaborate with the University of Cyprus for research and training purposes. All grade 4 ($n = 259$; 132 females and 127 males) and grade 6 ($n = 291$; 145 females and 146 males) students at each school were included in the initial sample. From this sample, two matched attention groups were selected each comprised of 49 participants on the basis of a stepwise group selection process.

Step I for Group Selection

The initial step for group selection involved the use of the non-verbal (Raven's Matrices) and verbal ability measures (Similarities and Vocabulary; Wechsler, 1992) in an attempt to control as many commonly identified variables as possible that could potentially influence group performance on the dependent measures of the study. To make the groups equivalent on these abilities, we excluded, from the initial grand sample of 550 children, those participants who had scored below the 25th percentile or higher than the 75th percentile on these cognitive measures. This screening resulted in a new grand total of 235 children.

Step II for Attention Group Selection

Next, to differentiate two groups of children based on attention and hyperactivity as perceived by their teachers, we selected the participants with the best (control group) and worst (Attention Difficulties group) scores on two scales, the Attention Checklist (ACL; Das, 1986, see Selection Criteria next) and the Hyperactivity scale (based on the diagnostic criteria of *DSM-IV*; APA, 1994, see Selection Criteria next). In the case of the Attention Checklist, the higher the score the better the attention, whereas in the case of the Hyperactivity scale, the higher the score the higher the hyperactivity. This selection resulted in an Attention Difficulties group with 64 participants and a control group of 60 participants, respectively, with the former falling into the lowest quartile on the ACL and the highest quartile on the Hyperactivity scale. The reverse holds for the control group.

Step III for Final Group Selection

Finally, these two groups were matched on parental education, gender, and age case by case resulting into two groups of 49 children each. Table I shows the group scores on non-verbal and verbal ability measures (raw scores are presented) along with the mean ages, gender distributions, parental education level, and anxiety scores for control and experimental groups, respectively.

In contrast, the attention groups differed significantly on a set of cognitive measures of attention (from the Das–Naglieri Cognitive Assessment System; Naglieri & Das, 1997) as Table II shows. The control group outperformed the AD group on all the cognitive attention subtests.

Table I. Data on the Demographic, Ability, and Anxiety Variables for Both Control and Attention Difficulties (AD) Groups

	Attention groups	
Variables	AD group	Control group
Age	10.17 (0.95)	10.09 (1.00)
Range	2.98	2.98
Gender		
Females	14 [28.6%]	15 [30.6%]
Males	35 [71.4%]	34 [69.4%]
Parental education level		
Less than HS	14 [28.6%]	11 [22.4%]
HS graduate	20 [40.8%]	23 [47.0%]
Some college	10 [20.4%]	8 [16.3%]
College graduate	5 [10.2%]	7 [14.3%]
Non-verbal ability		
Raven's matrices	15.96 (3.82)	15.61 (4.13)
Verbal ability		
Similarities	11.39 (3.63)	11.14 (2.88)
Vocabulary	18.39 (3.86)	19.98 (5.09)
Anxiety questionnaires		
State-anxiety	14.25 (3.79)	14.30 (4.37)
Trait-anxiety	15.07 (3.46)	14.14 (3.83)

Note. Values in parentheses are *SD*s; values in brackets are percentages.

Measures

Selection Criteria

Attention Checklist (ACL). The Attention Checklist was developed by Das (1986) for use by teachers to assess inattention in children. It is a 12-item checklist with a range of scores from 12 to 48, where a high score indicates good attention skills. Significant positive correlations between ACL ratings and students' scores on tests of attention, (particularly resistance to distraction) have been found in previous studies (Papadopoulos, Das, Kodero, & Solomon, 2002). In the same study, the internal consistency and inter-rater reliability of the ACL were found to be $\alpha = 0.95$ and $r = 0.75$, respectively. Das and Melnyk (1989) have shown that the ACL correlates with inattention symptoms rated on an abbreviated Conners Scale ($r = 0.84$). In the present study, the internal consistency of the ACL was $\alpha = 0.96$, whereas Guttman Split-Half reliability was = .95.

Hyperactivity Scale. Because of the absence of measures based on *DSM-IV* diagnostic criteria in the Greek language, a scale was constructed to measure hyperactivity for purposes of this study. The nine symptoms of the hyperactivity–impulsivity component of ADHD, as described in the *DSM-IV*, were represented, in nine corresponding questions. The scale was completed by each child's teacher who provided ratings of the

Table II. Data on the Behavioral Measures and the Measures of Attention for both Control and Attention Difficulties (AD) Groups

	Attention groups					
	AD group		Control group			
Variables	*M*	*SD*	*M*	*SD*	*F*-values	*d*
Attention checklist	26.28	(3.94)	44.94	(3.08)	681.49***	5.3
Hyperactivity scale	11.51	(2.37)	9.90	(2.01)	13.15***	.7
Expressive attention ratio	0.64	(0.17)	0.67	(0.16)	21.79***	.2
Receptive attention ratio 5	0.35	(0.06)	0.38	(0.07)	7.32**	.5
Receptive attention ratio 6	0.20	(0.03)	0.24	(0.04)	30.81***	1.1
Selective attention ratio 3	0.46	(0.12)	0.55	(0.12)	13.64***	.8
Selective attention ratio 4	0.13	(0.04)	0.15	(0.03)	4.98*	.6

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Note. $.2 < d < .5$ small effect size; $.5 < d < .8$ medium effect size; $d > .8$ large effect size.

child's behavior using a Likert-scale ranging from 1 (*not at all like him/her*) to 4 (*very much like him/her*). Internal consistency was $\alpha = .91$, and the Guttman Split-Half reliability = .84, for this scale.

Attention Measures. The attention measures used in this study were part of the Cognitive Assessment System (CAS; Naglieri & Das, 1997). The CAS battery is the main tool of PASS (Planning, Attention, Simultaneous, & Successive processing) model that has been proposed by Das and his colleagues (for a more recent review see Das, Naglieri, & Kirby, 1994) as a new view of intelligence. The CAS is comprised of 12 subtests that have undergone extensive development and validation (see Das et al., 1994; Naglieri & Das, 1997; Naglieri, 1999). Extensive reliability and validity data are presented in the CAS Interpretive Handbook (Naglieri & Das, 1997). Among these 12 subtests, attention tasks have been found to be effective in the assessment of individuals with attention deficits (e.g., Reardon & Naglieri, 1991).

Two types of attention tests are included in the battery measuring subcomponents of selective attention, namely, expressive and receptive attention (Das et al. 1994). *Expressive* attention is mostly related to inhibition with interference at the time of response (expressive stage) whereas *receptive* attention is mostly related to selection of factual information at the time of encoding (receptive stage). From the following tests, the expressive attention test corresponds to the former category, whereas the receptive and selective attention tests fall well within the latter category of attention tested (for further information the reader may refer to Das et al. 1994). These tests show correlations with a number of achievement, scholastic aptitude, written expression, intelligence, cognitive and neuropsychological tests, including the Woodcock–Johnson-Revised Tests of Achievement (WJ-R), Wechsler Intelligence Scale for Children-Third Edition (WISC-III), Trail Making Test and Stroop Color and Word Test, thereby attesting to their validity. Cognitive weaknesses on the attention tasks were mostly associated with lower scores in Dictation, Proofing, and Basic Writing Skills, in the case of the WJ-R substests, and Processing Speed and Performance IQ in the case of WISC-III. Similarly, the Trail Making Test and Stroop Color-Word Test revealed the highest correlations with the CAS attention tasks among the neuropsychological tests used (CAS Interpretive Handbook; Naglieri & Das, 1997).

Expressive Attention Test. This task is based on the Stroop task (1935), which has been widely used as a measure of interference and executive control (see McLeod, 1991; Nigg, 2001 for reviews). The version used in this study involved one trial of naming, as fast as possible, the color in which the words *red, blue, yellow*, and *green*, were printed instead of reading the words themselves. The index that was used in this test was the ratio score expressed by the time taken to complete the condition, divided by the number of correct answers given by the participants.

Receptive Attention Test. The development of this test was based on the work of Posner and Boies (1971). Participants were given two pages each consisting of 50 pairs of letters. The first page (item 5, the starting item for ages 8 and above, based on the published version of the CAS battery) contained visually alike letters among other dissimilar letter distracters. The child was required to circle all of the pairs of letters that were physically the same (*HH* but not *HN*; physical matching). The second page (item 6 of the CAS battery) was similar except that here the child had to circle all the pairs of letters that belonged to the same taxonomic category (e.g., *Aa* but not *Ba*; name matching). In both conditions, the ratio scores expressed as the time taken, divided by the number of correct responses, were used as the participants' Receptive Attention scores.

Selective Attention Test. This test presents the individual with a number of stimuli and requires selective responding, underlining numbers appearing in a particular form. Two conditions of this task were presented. In the first presentation (Item 3 of the CAS battery), the targets were the digits "1," "2," and "3," which had to be underlined only in the case they were presented in bold (as opposed to regular print). In the second phase of this task (Item 4 of the CAS battery), the digits "1," "2," and "3" had to be underlined only when in bold, whereas the digits "4," "5," and "6" had to be underlined only when in regular print. Any other form of either set of targets was ignored. The participants were aware of a 90-s time limit during both conditions. In both conditions, a ratio score expressed as the time elapsed, divided by the number of correct responses, was used as the participants' Selective Attention score.

Cognitive Performance Measures

Planning: Crack-the-Code. Crack-the-Code is based on the popular Master Mind game and the electronic version of it has been used to measure planning in several previous studies (see e.g., Papadopoulos & Parrila, 2000; Papadopoulos, Parrila, & Das, 2001; Parrila, Das, & Dash, 1996; Parrila, Papadopoulos, & Mulcahy, 1997). In the Crack-the-Code task, participants are shown two to five information lines that contain three to five colored disks in a particular order (representing three increasing levels of difficulty), followed by labels indicating how many of the colored disks are in their correct places. The participant's task is to integrate information from all of the information lines and place the disks, located randomly on the left side of the screen, on the answer line in such an order that all of the information lines are true. The time limit for each item is 3 min. A graphic representation of Item 1 is presented in the Appendix.

The version used in this study consisted of six items presented on a computer (Power Macintosh with 15 in. color monitor). The six items can be divided into three pairs of formally similar and progressively more difficult items. In the first two items, two information lines and three colored disks were used. Items 3 and 4 consisted of four disks and four information lines, and Items 5 and 6 had four disks and three information lines. Despite having fewer information lines, Items 5 and 6 are more difficult because they have fewer matching placements in different information lines, and thus, less readily detectable constraints for the planned moves.

The computer recorded each participant's performance and provided the following information regarding C-t-C task: (1) the Total Number of Correct items, (2) the Total Performance Time (as an indicator of strategy execution), (3) the First Move Latency (as an indicator of strategy planning), and (4) the Total Evaluation Time (as an indicator of self-regulation). These indexes make C-t-C a particularly useful task for assessing planning skills in children with attention deficits, as they allow one to tap different aspects of EF performance. By emphasizing the process rather than the outcome of performance, the C-t-C can help one examine specific areas of potential deficiencies in planning among AD children, as previous research with same age populations has shown (Papadopoulos & Parrila, 2000; Papadopoulos et al., 2001). Parrila et al. (1996) have used the C-t-C task to examine development of planning skills in children aged 8 to 17 years old, and provided evidence for the developmental appropriateness of the task for the present sample. The same study provides information about mean performances of normal children at different age groups.

Flexibility Measures

Embedded Figures. In this task, participants were shown a page with five information lines containing 25 stars. The participants' task was to trace with a colorless pen as many full shapes as possible (e.g., triangles, hexagons, parallelograms, trapeziums, rhombuses, sandglass) throughout the page within 60 s. The scores used were the total number of correct full shapes produced excluding repetitions, the total number of repetitions, and the number of unique shapes traced (i.e., subtracting total repetitions from total correct).

Ambiguous Figures. In this task, participants were shown five traditional ambiguous figures (the rabbit, the vase, the arrows, the old woman, and the cow-boy). Participants' task was to name in 60 s the two figures that could be possibly identified in the stimulus. The total number of correctly identified figures was the participant's score.

Theory of Mind

The goal of this task was to determine whether the child can concurrently keep in mind and manipulate factual information derived from the text, showing that s/he is able to make inferences about the story characters' actions and beliefs as described in the story. This task included both first- and second-order tasks and was adapted from Benson, Abbeduto, Short, Nuccio, and Maas (1993). The first-order task consisted of only one episode, followed by three factual questions (not included in the scoring) asked by the interviewer. The aim of the questions was to check whether the child had retained crucial elements of the story in order to next answer four content questions: 1 *ignorance*, 1 *belief*, 1 *justification*, and 1 *knowledge question*. The second-order task consisted of a longer and more complex story with three episodes followed again by four factual (not included in the scoring) and four content questions. The questions had the same rationale as in the first-order story, including 1 *ignorance*, 1 *belief*, 1 *justification*, 1 *knowledge*. For each correct response children received two points and for each partially correct response, one point, resulting in a total correct score for each task order. See the Appendix for the ToM items, of first and second order, used in the study.

Anxiety Questionnaires

The two scales (state and trait) based on the State–Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, & Lushene, 1970) were used to assess anxiety. Given that neither of these scales had been adequately validated with Greek populations, we proceeded with our own front and back translations and adaptations of the measures. Each resulting scale consisted of only eight items in order to limit administration time. The trait measure was used to track chronic anxiety symptoms (i.e., as an analog to clinical anxiety) and the state measure focused on the presence and absence of symptoms of nervousness and tension. The latter was included, because it is likely for anxious individuals to demonstrate the most anxiety under conditions that are perceived as overly challenging, in the context of their specific anxious concerns (Barlow, 1988). Both subscales were administered prior to the performance measures and were based on a 4-point Likert scale (with higher scores indicating more anxiety). Cronbach α reliabilities for these two scales were as follows: State anxiety: $\alpha = .71$ and Trait anxiety: $\alpha = .70$, and the correlation between the two was $r = .66$, $p < .01$. The overall group mean score was Mean (90) = 14.32, $SD = 4.13$, for the State Anxiety, and Mean (94) = 14.55, $SD = 3.71$, for the Trait Anxiety measure. Projecting these scores on a 20-item scale, to correspond to the original Spielberger measures from which the questionnaires were drawn, the predicted means were almost identical to the normative means reported in the manual (Spielberger et al., 1970). However, the ranges of scores in the present sample were somewhat low indicating low levels of anxiety in the overall sample, as shown in Table I.

Procedure

Testing was completed in two phases. The first phase consisted of the matching procedure described above (see participants section). During both phases, participants were tested individually. All testing took place during school hours in a private room in the participants' respective schools. Experimenters were trained undergraduate research assistants enrolled in educational psychology courses, blind to the grouping of children as AD or control. Children were not informed of the aims of the testing. Instead, they were told that they were participating in a project aiming at developing a new battery of computerized learning material and that they had been randomly selected. By selecting both control and AD children from each class, the cover story of random selection was made more convincing.

Testing preparation, for C-t-C included three sample items with feedback regarding the correctness of participant answers to ensure that all participants knew what was expected of them.

RESULTS

In the first phase of testing, the two attention groups were compared in their performance on a set of problem solving tasks. The interactive role of anxiety was also examined. Given the relatively small sample sizes, these two independent variables were tested in separate ANOVAs in order not to reduce the number of degrees of freedom for testing our main hypothesis regarding the effect of attention group on performance. Gender and grade level were not included in any of the analyses, as an initial exploration indicated no significant gender or grade level differences on any of the measures.

Group Differences on Cognitive Performance Measures

A series of one-way ANOVAs corresponding to each of the dependent variables (as showed in Table III) tested differences between AD and control groups on all performance measures. It can be seen that AD children scored significantly more poorly than controls on total number of C-t-C items, although the modal performance was similarly low in both groups (Mode = 2, for both groups). The AD group took less time initially to plan the task (First Move Latency) and took marginally longer to evaluate each finished item before moving on to the next one (Total Evaluation

Table III. Group Means, Standard Deviations (in Parentheses), and Significant Differences on Measures of Cognitive Performance

	Attention groups					
	AD group		Control group			
Variables	*M*	*SD*	*M*	*SD*	*F*-values	*d*
C-t-C						
Total number correct	2.14	(1.32)	3.06	(1.52)	10.18**	.7
Total performance time	49.33	(20.53)	55.55	(25.87)		
First move latency	63.62	(44.56)	88.75	(57.88)	5.80*	.5
Total evaluation time	5.48	(3.70)	4.25	(2.60)	3.66*	.4
Ambiguous figures						
Total correct	5.16	(1.30)	4.95	(1.30)		
Total time	178.96	(79.44)	172.19	(74.68)		
Theory of mind						
First order	3.67	(0.71)	3.57	(0.77)		
Second order	2.69	(0.85)	3.05	(0.76)	5.37*	.5
Embedded figures						
Total correct	9.13	(5.60)	8.98	(5.28)		
Total repetitions	2.73	(4.20)	3.12	(4.42)		
Total correct unique	6.27	(2.77)	5.78	(2.37)		

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.
Note: C-t-C = Crack-the-Code task; $.2 < d < .5$ small effect size; $.5 < d < .8$ medium effect size; $d > .8$ large effect size; F-values and effect sizes are provided only for significant group comparisons.

Time). AD children also performed significantly more poorly than controls on the more difficult second-order Theory of Mind task. There were no significant attention group differences on any other cognitive performance measures.

As described above, the C-t-C task involved an increasing level of difficulty as the participant progressed through the measure. Thus, items 1–2, 3–4 and 5–6 represented three upward steps with regard to complexity. A series of ANOVAs were conducted with the Total Number of Correct items, First Move Latency, Total Performance Time, and Total Evaluation Time collapsed for the two items at each level, in order to test attention group processing differences at different levels of difficulty on C-t-C accuracy and latency measures. Results indicated that the attention group differences observed, in total number of correct items, was due to the significant group differences on the two most difficult levels of the C-t-C task: for difficulty levels 2 and 3 were $F(1, 96) = 9.24$, $p < .01$ and $F(1, 96) = 4.57$, $p < .05$, respectively. The same pattern applies to the First Move Latency, where AD children appeared to plan ahead significantly less when performing the two most difficult levels: $F(1, 96) = 6.51$, $p < .05$ and $F(1, 96) = 9.65$, $p < .01$, for second and third level of difficulty, respectively. Conversely, with regard to the Total Evaluation Time, the attention group differences were located at the first level of difficulty, with the AD group taking longer to finalize the task, $F(1, 96) = 5.62$, $p < .02$.

At the next step of analysis, we examined the attention group differences in the C-t-C latency measures separately for the number of correct and incorrect responses. The total scores described above give a global picture of how AD and control children approach the task, allowing one to examine how their total allocation of time and effort results in group differences in correct responses. However, the analysis does not allow us to see how the two groups may process information and allocate time differently within those items that they finished correctly. Toward this end, a series of Repeated Measures ANOVAs, one for each time measure was conducted. In each analysis, the within factor involved was the two levels of correct (correct and incorrect), for each of the six items, and the between factor was groups (AD and control) leading to a 6 (C-t-C items) × 2 (correct/incorrect) × 2 (attention groups) design. Among the three latency measures used in this analysis, only First Move Latency revealed significant attention group differences, with the control group appearing to think significantly longer (based on post hoc planned comparisons) before manipulating the chips on the screen on items solved correctly compared to the AD group, $F(1, 96) = 5.08$, $p = .026$. Figure 1 displays attention group performances on time measures in relation to correct and incorrect performance.

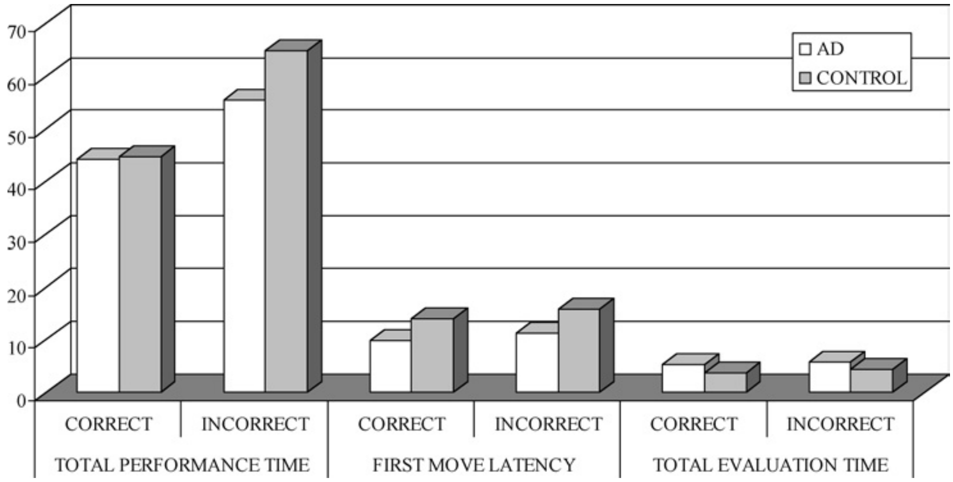


Fig. 1. Attention group performances on time measures in relation to items performed correctly/incorrectly.

Anxiety and Performance

Results regarding anxiety are limited by the fact that anxiety levels in our sample appeared to be in a subclinical range, as Table I shows. In spite of this, we proceeded with an analysis to test the study's hypothesis whether anxiety buffers attention effects on performance, because high and low anxiety groups for each of the attention groups were significantly different on both State and Trait Anxiety, all comparisons at .001 level, as shown by t-test analyses. Anxiety grouping (based on the median split) was used as a between participants' variable, along with attention group, in a MANOVA with the two anxiety measures as grouping variables and the two cognitive measures (total Correct C-t-C items and Theory of Mind second order) on which attention group differences had been obtained, as the dependent variables [a 2 (attention groups) $\times$ 2 (state anxiety groups) $\times$ 2 (trait anxiety groups) design]. The overall MANOVA revealed no significant interactions between anxiety and attention.

DISCUSSION

The present study examined the performance of children selected for attention difficulties (AD) and a matched control group on a number of complex EF tasks, in order first to examine the possible mechanisms underlying the deficits in the performance of AD children. The tests used in the present study were selected to be different from those used in relevant previous studies. First, by emphasizing the process, through the inclusion of various latency measures, rather than the outcome of performance alone, the C-t-C allowed us to examine specific areas of potential deficiencies in planning among AD children. Second, although the Flexibility tasks (Embedded and Ambiguous Figures) and Theory of Mind have also been previously linked with EF (Brosnan et al., 2002; Perner et al., 2002) this is one of the few studies that incorporates tasks covering such a wide range of executive function skills with AD populations. Our prediction was that the children with attention difficulties would show circumscribed deficits on planning tasks, compared to the control group. Results confirmed our prediction for some of the most demanding tasks and coincided with the findings of previous studies that have demonstrated the inability of AD children to generate and execute their own plans and evaluate their performance when engaged in cognitively challenging tasks (Barkley, 2003; Naglieri et al., 2003; Perchet et al., 2001).

A secondary aim of the study was to examine the possible role of anxiety in buffering executive function deficits. Our prediction was that performance of AD children on measures that require selective attention, inhibition of impulsive behavior, flexibility, and strategic planning would benefit from the co-existence of anxiety, as prior research has documented (Manassis et al., 2000; Nigg, 2001). Results did not support this prediction. Results relating to the primary and secondary goals of the study are discussed in more detail below.

Planning Ability

The significant differences expected between the two attention groups with regard to cognitive performance were observed. Results indicated that planning ability clearly differentiated AD from control children.

Specifically, AD children scored significantly worse than controls on total number of C-t-C items performed correctly despite the small number of items and the fact that the test appeared to be difficult overall. At the same time, they took significantly less time to initially plan the task as was evident from their scores on First Move Latency. This pattern of approaching the C-t-C task was evident especially in the case of the correctly solved items. These results point to profound difficulties in strategically organizing a successful execution of this planning task before beginning execution among the AD group. Kempton et al. (1999), Perchet et al. (2001), and Klorman et al. (1999) similarly found significant impairments among ADHD children on EF tasks such as planning and set-shifting, possibly reflecting strategic and anticipatory mechanism deficiencies.

Task difficulty may have contributed independently to the differential performance of our AD group on the C-t-C task. Children with attention deficits and/or hyperactivity have been shown to exhibit greater difficulties when the complexity of the task increases (Douglas, 1983; Luk, 1985). This was confirmed in the difficulty-level analysis of the C-t-C task showing significant differences between attention groups in total number of correct and in two of the three latency measures used: the First Move Latency and Total Evaluation Time: The AD group performed significantly worse than the control group on the two most difficult levels of the task, spending comparatively and significantly less time initially thinking about and planning their strategy (First Move Latency) than the control group on the corresponding levels of difficulty. Simultaneously, the participants in the AD group appeared to spend comparatively more time evaluating their complete answer at the end of the task, especially on the two easiest difficulty levels, which, however, did not result in correspondingly better performance compared to the control group.

These results speak to the two groups' differential approaches to the task: the control group appeared to rely on a planning in advance approach to a greater degree than the AD group, especially on the more difficult items. Thus, the control group seemed to approach the task in a more thoughtful manner, resulting in more accurate overall performance compared to the accuracy of the AD group. Overall, the superior correct performance of the control group suggests that the planning before action approach used by the control group was more effective for this task.

Theory of Mind and Flexibility

Further evidence in support of the deficiencies experienced by the AD children on executive function tasks can be derived from their performance on the second-order Theory of Mind task, requiring notably higher inhibitory control and executive functions. AD children performed significantly worse than controls on this measure. The first-order Theory of Mind tasks, however, did not show significant group differences, as would be expected from previous findings (Happé & Frith, 1996; Perner et al., 2002).

Buitelaar et al. (1999) have also found significant differences on second-order false belief tasks in a clinical sample of 9 ADHD children as compared with 11 psychiatric control children. This finding, however, is not consistently present in other relevant research (Charman et al., 2001; Perner et al., 2002). It is likely that these studies might have failed to find significant differences because of methodological differences. In the case of the Perner et al. study, at least, the small sample size might have accounted for the lack of significant findings on the ToM second-order story: there were only four predominantly inattentive children (among the other subtypes of children participating in their study). All things considered, however, the present findings need to be replicated to verify the relation between attention deficits and ToM performance.

As for the flexibility tasks, no significant attention group main effects were observed on either embedded or ambiguous figures. Although these measures have been found to reflect disinhibition and executive control deficits, in the past, among adults with dysfunctional impulsivity (e.g., Brunas-Wagstaff et al., 1996), and dyslexic populations (e.g., Brosnan et al., 2002; although they used a slightly different task), they have not been used specifically with attention deficits (with the exception of the earlier works of Douglas, Campbell and their associates) and, hence, may not be appropriate for discriminating attention difficulties in children. At the very least, their predictive utility for discriminating AD needs further validation. To the degree the present results are replicable, they may also mean that pointing to ground-figure relationships and figure identification rely more on the perceptual system, which might not be severely interfered with by inattention and disinhibition. Once more, replication of the present findings is necessary before one can definitively conclude that performance on these specific measures of EF is not impaired by attention deficits.

Planning Ability in Relation to Core Cognitive Functions

Overall, it was found that children with attention problems had worse performance on the planning tasks, both in the C-t-C and ToM, especially in the case of the more complex items. Performing more poorly on the most difficult items in both tasks might be explained by group differences in utilizing core cognitive functions relevant to planning ability (Das, Kar, & Parrila, 1996; Kuntsi, Oosterlaan, & Stevenson, 2001; McInnes, Humphries, Hogg-Johnson, & Tannock, 2003). For instance, speed of processing, working memory, and inhibition have been linked previously to planning performance. If we had included tasks assessing each one of these processes, the clarification of their roles in planning would have been enhanced. That is, working memory may have been a possible interpretation for the group differences observed in the second-order theory of mind task and the most difficult items of the C-t-C (Das et al., 1996). Barkley (1998) considers working memory to be an essential part of planning, and therefore, an integral component of EF, that helps to link past experiences with future goals.

However, we considered planning as a unitary ability and examined it as a manifestation of all the above integrated components, in an attempt to test the hypothesis of an overarching cognitive deficit that is apparent in the performance of children with attention difficulties. That was the reason that we included specifically C-t-C, ToM, and other executive function tasks. Thus, we started with the assumption that all these planning components (i.e., speed of processing, working memory, inhibition) are almost by definition deficient in the case of AD children, as has been shown in numerous previous studies.

Anxiety and Executive Control

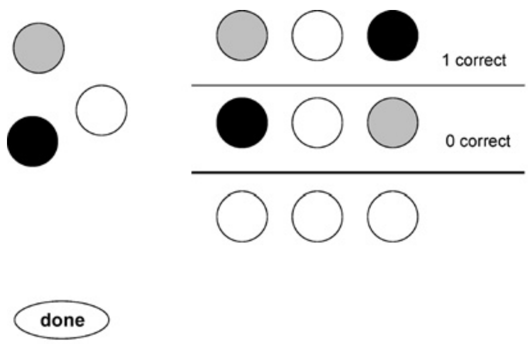
No significant interactions between anxiety and attention groups were observed, indicating that state and trait anxiety did not affect the group performance differentially. This outcome does not provide any support for the questions posed by Nigg (2001), who wonders whether "...anxiety may partially buffer an ADHD deficit" (p. 580) on executive control tasks. Perhaps the reason that we did not find significant interaction between attention and anxiety lies in the relatively low levels of anxiety observed in this sample.

CONCLUSIONS

In sum, the present study clearly demonstrates the presence of pronounced deficits in planning and strategic problem solving among AD children. The deficits appear to be primarily circumscribed in the processes of planning one's activity *ahead*. Simultaneously, the study has not supported the assertion that anxiety buffers AD children against their EF deficits. What this study has offered to the ongoing discussion about the cognitive difficulties of AD individuals is that it demonstrates the presence of some intriguing differences on planning and strategy development using a number of different EF tasks, and by looking at process through the use of time measures. The absence of anxiety effects in the present study provides the impetus of further research to either verify of falsify the buffering hypothesis: At least with regard to low levels of anxiety, no buffering was observed in the present study.

APPENDIX

Crack-the-Code: Item 1



Item 1

Note: The disks in grey actually appeared in blue in the colored version on the computer screen

Theory of Mind Measures

To test Theory of Mind (ToM), two false-belief stories were devised; they both were similar in length but differed in complexity.

First-Order Story

The person X was riding his new bike in a park while his friend Y was watching him. Then X placed his bike under a tree nearby and told his friend Y not to ride the bike because X would come back soon to ride it again. After that, X left to meet another friend in the park. Y was angry at X's behavior; he liked to ridicule him. So, Y hides X's bike behind the guard's house in the part and goes back, where X meant to return after meeting his other friend.

To check the participants' retention of key-points of the story, they had to answer correctly factual questions, which were not scored. Immediately after, participants had to respond to the following four questions that assessed their *false-belief knowledge*:

(a) An *ignorance* question: Did X know where his bike was hidden?
(b) A *belief* question: Where was X going to look for his bike?
(c) A *justification* question: Why?
(d) A *knowledge* question: Did X know where Y hid his bike?

Second-Order Story

The person X going to school passed through the Grand Park. There, X met his friend Y who was playing with a colorful balloon. Y bought his balloon from Mr Z. X told Mr Z that he would also buy a balloon when coming back from school, if Mr Z would stay in the Grand Park till then. Mr Z promised he would stay and X left to go to school. Y, X's friend, and Mr Z stayed in the Grand Park. Soon after, a group of children visited the Grand Park and bought all Mr Z's balloons. Mr Z told Y, X's friend, that he would leave and go to the downtown to get some new balloons. Y also left the Grand Park to play with other friends. As Mr Z passed by X's school, X saw Mr Z and asked him why he left the Grand Park although Mr Z told X he would stay there. Mr Z told X that he sold out all the balloons and was going to the downtown to buy new ones and stay there all-day long.

Similar questions, as in the first-order story, were used in this case.

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