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A controlled study of a simulated workplace laboratory for adults with attention deficit hyperactivity disorder

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Abstract

Despite an extant literature documenting that adults with Attention-Deficit/Hyperactivity Disorder (ADHD) are at increased risk for significant difficulties in the workplace, there is little documentation of the underlying factors associated with these impairments. The main aim of this study was to examine specific deficiencies associated with ADHD on workplace performance in a simulated workplace laboratory relative to controls. Participants were 56 non-medicated young adults with DSM-IV ADHD and 63 age and sex matched controls without ADHD. Participants spent 10 hours in a workplace simulation laboratory. Areas assessed included: 1) simulated tasks documented in a government report (SCANS) often required in workplace settings (taxing vigilance; planning; cooperation; attention to detail), 2) observer ratings, and 3) self-reports. Robust findings were found in the statistically significant differences on self-report of ADHD symptoms found between participants with ADHD and controls during all workplace tasks and periods of the workday. Task performance was found to be deficient in a small number of areas and there were few statistically significant differences identified by observer ratings. Symptoms reported by participants with ADHD in the simulation including internal restlessness, intolerance of boredom and difficulty maintaining vigilance were significant and could adversely impact workplace performance over the long-term.

Keywords

workplace; employment; adult ADHD; self-report

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Conflict of Interests

In the past, Ronna Fried has received honoraria from Shire.

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a well-recognized neurobiological disorder affecting individuals across the lifespan (Spencer et al., 1998; Biederman et al., 2006) affecting up to 5% of the adult population (Faraone and Biederman, 2005; Kessler et al., 2006). Among the many recognized functional impairments in adults with ADHD are impairments in the workplace (Kessler et al., 2005; Biederman et al., 2006). Considering the clinical features of inattention, distractibility, and impulsivity that define this disorder, it might well be hypothesized that these symptoms could detrimentally affect work performance (Barkley, 2001; Castellanos et al., 2006). Likewise, the literature on boredom as being a key feature in adults with ADHD suggests this symptom might be a factor in poor workplace performance or longevity in a job (Weyandt et al., 2003; Torrente et al., 2011). In fact, the Utah group's rating scale for adults with ADHD (Wender, 1995) boredom was considered a primary symptom in ADHD.

Moreover, the U.S. Secretary of Labor's Commission on Achieving Necessary Skills (SCANS) (Wise et al., 1990) identified many of the skills that correspond to domains of weaknesses associated with ADHD. The SCANS report emphasizes that workplace success requires workers to have solid "basic skills" including basic literacy, computational skills, and "thinking skills" necessary to put knowledge into work. Thinking skills include allocating time, acquiring and evaluating information, identifying and conveying main points, focusing on tasks at hand, interjecting opinions appropriately, communicating ideas effectively, recognizing and solving problems, and effective self-management. These skills are often deficient in individuals with ADHD (Nigg, 2006).

Clinical and epidemiological data clearly document that adults with ADHD are at significant risk of unemployment, underemployment, and job loss (Biederman et al., 2006). Longitudinal studies of ADHD children grown up document that individuals with ADHD change jobs more frequently, hold multiple jobs concurrently, and experience less satisfaction on the job (Weiss and Hechtman, 1993; Biederman et al., 2006). A recent study of adults with ADHD documented that ADHD is associated with significant occupational under-attainment relative to what would have been expected by intellectual potential (Biederman et al., 2008). An economic impact survey (Biederman and Faraone, 2006) documented that the average loss of household income per person with ADHD ranged from \$8,900 to \$15,400 per year, which translated into an annual loss in household income of 67 to 116 billion dollars. Despite these stark realities, there are limited studies investigating the nature of workplace deficits in adults with ADHD. Thus, the identification of workplace deficits in adults with ADHD is of high clinical, scientific and public health relevance.

To date, the studies that assessed occupational outcomes (Weiss et al., 1979; Mannuzza et al., 1993; Kessler et al., 2005) in adults with ADHD relied on interviews and checklists in order to gather workplace data. Although gathering information on workplace performance from the employer may be ideal, and could be integrated into a research study, in clinical practice this approach is neither practical nor ethical. One approach to investigate workplace deficits in adults with ADHD is through the use of a laboratory workplace simulation paradigm. This approach can provide unique insights into the behaviors that co-workers and supervisors observe, and the circumstances that create heightened vulnerability that lead to adverse workplace performance in adults with ADHD. However, for a work simulation paradigm to be informative it must demonstrate meaningful differences between ADHD participants and controls. To the best of our knowledge, there have been only two prior studies utilizing a work simulation paradigm. Although Wigal and colleagues (2010) investigated the efficacy of a stimulant medication for ADHD in a simulated laboratory

workplace, because this laboratory simulation did not first differentiate work performance of ADHD subjects from controls, their results are difficult to interpret.

The second study was conducted by our group (Biederman et al., 2005), where we showed significant differences between individuals with ADHD and controls in a full day work simulation laboratory. However, this preliminary study included a small number of participants (18 with ADHD and 18 without ADHD), thus, more work in larger samples is needed to replicate and confirm initial findings.

The objective of this study was to validate a novel paradigm specifically developed to measure workplace behavior in adults with ADHD. To this end, we compared workplace performance in a laboratory setting in a well-powered large sample of adults with and without ADHD. We hypothesized that adults with ADHD would show impairment on tasks requiring sustained attention, would self report more symptoms of ADHD across the day and would exhibit symptoms of ADHD that would be observable to objective raters. To the best of our knowledge, this represents the largest effort to date to establish the validity of a laboratory workplace simulation suitable for ADHD research.

2. Methods

2.1. Participants

Participants were adults between 18 and 55 years of age of both sexes, recruited from clinical referrals and advertising in the local media. Interested participants underwent a telephone-screening questionnaire that asked about symptoms of ADHD, as well as study inclusion and exclusion criteria. An expert clinician completed a comprehensive psychiatric evaluation, which included a detailed assessment of ADHD based on DSM-IV criteria, and either confirmed or ruled out (for controls) the diagnosis of ADHD. To be given a full diagnosis of ADHD, the participant must have endorsed full DSM-IV criteria and described a chronic course of ADHD symptoms from childhood to adulthood. The institutional review board approved this study and all participants completed a written informed consent before inclusion in the study.

We excluded potential participants if they had major sensorimotor handicaps (e.g. deafness, blindness), psychosis, autism, inadequate command of the English language, or a full scale IQ less than 80. Participants with any psychiatric condition in the past year that was determined to be clinically significant and/or unstable (e.g., Major Depressive Disorder or Bipolar Disorder, Panic Disorder, Obsessive Compulsive Disorder, substance use disorders), as well as suicidality, or evidence of sociopathy, criminality were also excluded. In addition, study participants could not be receiving any psychotropic medications currently or in the past year, or have taken any stimulant medication for ADHD within the past month. No ethnic or racial group was excluded.

2.2. Assessments

All participants were assessed with the Structured Clinical Interview for DSM-IV (SCID) ((First et al., 1997) supplemented with modules from the Kiddie Schedule for Affective Disorders and Schizophrenia- Epidemiologic Version (KSAD-E) adapted for DSM-IV (Orvaschel, 1994) to assess ADHD and other childhood disorders. The interviewers had undergraduate degrees in psychology, and they were trained to high levels of inter-rater reliability for the assessment of psychiatric diagnoses. Initial diagnoses were reviewed by a committee of board-certified psychiatrists or licensed psychologists blind to the participant's ascertainment group. Diagnoses were considered positive if, based on the interview results, DSM-IV criteria were unequivocally met to a clinically meaningful degree. Based on 500 interviews, using identical methods, we estimated the reliability of the diagnostic review

process by computing kappa coefficients of agreement between clinician reviewers. Kappa coefficient for ADHD was 1.0.

Participants also underwent a psychiatric evaluation by a board certified psychiatrist with expertise in adult ADHD. To have been given a full diagnosis of adult ADHD, the participant must have: a) met full DSM-IV-R criteria (at least 6 of 9 symptoms) for inattentive and/or hyperactive/impulsive subtypes by the age of seven as well within the past month b) described a chronic course of ADHD symptomatology from childhood to adulthood; and c) endorsed current impairment attributed to the ADHD symptoms.

2.2.1. Cognitive testing—Neurocognitive measures were administered by trained psychometricians who were blind to diagnostic/ascertainment status and who received ongoing supervision by a licensed clinical neuropsychologist. The neuropsychological battery were administered in a fixed order: 1) Wide Range Achievement Test (WRAT; Math), 2) Wechsler Abbreviated Scale of Intelligence (WASI; Vocabulary), 3) the WAIS-III Digit Span, 4) D-KEFS Color-Word Interference Test, 5) WAIS-III Digit/Symbol Coding, 6) WASI (Matrix), 7) WAIS-III Letter Number Sequencing subtest, 8) WAIS-III Symbol Search, 9) Test of Word Reading Efficiency (TOWRE), 10) WAIS-III Oral Arithmetic, 11) D-KEFS Trail Making (Jastak and Jastak, 1993; Wechsler, 1997; Delis et al., 2001). In addition to these subtests, modules from the Cambridge Neuropsychological Test Automated Battery (CANTAB) (Robbins et al., 1998) were administered: Verbal Recognition Memory (VRM); Intra-Extra Dimensional Set Shift (IED); Spatial Working Memory (SWM); Stockings of Cambridge (SOC); Reaction Time (RTI); Rapid Visual Information Processing (RVP); Affective Go/No-Go (AGN).

2.2.2. Self-reports—Throughout the day, ADHD symptoms were assessed by both observers (see below for details) and self reports. After each structured and unstructured period, participants were asked to complete self-evaluations measuring symptoms that they may feel, but that may not be observable. The self-report rating scale measures symptoms of hyperactivity and inattention and consists of five different categories (overwhelmed/felt mind swimming, trouble focusing, trouble sitting still, bored, and having a hard time keeping quiet), which the participants ranked on a scale from 0 (not at all) to 10 (extremely).

2.3. Simulated workplace laboratory

The laboratory workplace was designed to simulate a full work day with participants arriving at 8:30 a.m. and departing at 6:30 p.m. (Table 1). The number of individuals in each session ranged from six to eleven, half ADHD and half control participants. Within the 10-hour day, there were three periods each of structured and unstructured time of 90 minutes each, and a lunch hour. During the structured periods, participants worked on specific tasks with predetermined times for the completion of each task. During the unstructured periods, participants were given a packet containing a variety of tasks and distracters with the only instruction given that the packets were due by the end of the day. A detailed instruction manual was used with pre-recorded directions for tasks to ensure consistency. Tasks were designed to elicit DSM-IV symptoms of ADHD and to provide objective measures of work performance. During tasks, participants were rated blindly by trained observers using strictly defined measures of behavioral observations and participants completed self-evaluations measuring symptoms of or associated with ADHD.

2.3.1. Workplace simulation tasks

2.3.1.1. Structured periods: During the structured periods of the workplace simulation day, participants were asked to complete seven specific tasks within 1 hour and 30 minutes.

Video: Participants viewed a 25-minute educational video. In the last 5 minutes, participants were asked to complete six questions of comparable difficulty about each section of the video.

Math: The 3-Minute, 160-item math fluency tests were taken from the Woodcock-Johnson Test of Achievement (Woodcock et al., 2001) and from the Permanent Product Measure of Performance (Swanson et al., 2000). The questions started with simple addition and subtraction problems and moved on to include multiplication and division. Participants were allotted 5 minutes to complete this task.

Lecture: The lecture task was derived from the note-taking task of the Process Assessment of the Learner (PAL) Test Battery for Reading and Writing (Berninger, 2001) adapted for adults, which assessed the ability to listen to a lecture, take notes and use the notes to answer questions. The content of the lecture was taken from subtests of the Nelson-Denny Reading Test (Brown et al., 1993). The lecture task had two parts. In the first part, participants were instructed to listen to a recording of 2-minutes, while taking notes on content. After listening to the lecture, the notes were collected from the participants. After some interference activities (see below), the notes were returned to the participants who were then instructed to answer questions regarding the lecture using their notes. Participants were allotted 15 minutes to complete this task.

Reading comprehension: The Qualitative Reading Inventory-4 (QRI-4; (Leslie and Caldwell, 2001) was utilized during both the structured and unstructured periods of the work simulation day. The QRI-4 is a reading inventory designed to assess silent reading and reading comprehension. The texts from this reading inventory were chosen because they were similar to the types of reading that might be required by persons in the workplace; they were lengthy, but did not contain obscure vocabulary. There were questions after each of the passages and the text was available to the participants to refer back to for answers. Participants were allotted 20 minutes to complete the reading comprehension task.

Editing: Participants were presented with brief typed documents containing intentional spelling, grammar, formatting, and referencing mistakes. Participants had 10 minutes to review each document and were asked to circle all mistakes in red pen.

2.3.1.2. Unstructured periods: During unstructured periods, participants were asked to work on a packet, containing a variety of tasks and distracters. In the packet there was a list of tasks that were required. Collection boxes for the completed tasks were provided and were replaced with new empty boxes at each deadline time so that on-time completion could be tracked throughout the day. Participants were expected to monitor their time and meet the deadline for each task in the packet without guidance or reminders from the work simulation day monitor.

Forms and questionnaires: Participants were asked to complete a number of forms during each unstructured period. These forms included the Social Adjustment Self Report Questionnaire (Weissman, 1995), the Drug Use Screening Inventory (Tarter and Kirisci, 1997), Barkley Employment History (Barkley and Murphy, 1998), the Beck Depression Inventory (Beck et al., 1961), the Driving Behavior Questionnaire (Reimer et al., 2005 18497), the Quality of Life Enjoyment and Satisfaction Questionnaire (Endicott et al., 1993), a Sample Dietary Assessment, and a generic employment history form. Additionally, a request for a parking validation sticker was included in the packet. Participants were instructed that the forms must be completed by the end of the day.

Logic: Logic tasks taken from Law School Admission Test (Stewart, 2007) practice examinations were administered to assess teamwork and coworker perceptions of behavior. Alternative forms of this test were administered during a second and third task in the afternoon. Participants were asked to complete the tasks in assigned groups of four people. Group membership was changed for the second and third logic task assignments. After turning in the completed logic task, a peer report form was distributed to all group members and they were asked to report on the behaviors of each group member during the task. Group members were given color-coded tags in place of names. Items on the peer rating scale were scored on a scale of 0 to 2 (0=Never; 1=Sometimes, and 2=Often). A participant's total score was a sum of the ratings given to the participant by the two other group members across all three exercises. A participant's total score may range from 0 (worst possible) to 96 (best possible).

Writing: We administered writing tasks of the Wechsler Individual Achievement Test, which is written for adults, one from the WIAT I, and two from the WIAT II.

Computer tasks: Participants were given detailed instructions on how to log into Microsoft Outlook. They were also given specific directions on sending an exact message to four different fabricated email addresses and were told that the e-mail should have their participant code in the headline so the coordinator was able to identify the participants when scoring this task.

Product orders: Participants were given three catalogs containing information about various products as well as order forms. Participants were asked to place orders based on specifications from the catalogs using order forms.

Distractor tasks: The work simulation packets contained, in addition to materials for required tasks, items intended to distract the participants. Such items include sudoku and crossword puzzles, reading materials, and a gift certificate to the hospital gift store. Participants were told they may use these materials during down time and that they were free to take breaks or leave the room as they pleased during unstructured time. Participants were told explicitly that these tasks were optional. Behavior related to distractors was documented through the Observer Rating Inventory (ORI) that is discussed below.

2.4. Observer rating inventory

Blinded observers were seated in the simulation room to document hyperactivity and inattention (see below for details). Each rater observed three or four participants. They did not interact with participants. In order to monitor inter-rater reliability, two video cameras were placed at the front of the room to record participants' behavior.

2.4.1. Observer ratings during structured period—During structured tasks, raters documented participants' behavior throughout each task. The ORI rating system was broken into two classifications of behavior: Inattentive and Hyperactive, based on DSM-IV criteria of ADHD. The scale also measured the severity of ADHD behavior based upon frequency, duration, impairment to others, and interference with task completion (range 0-4): 0=None (No behaviors); 1=Mild; 2=Moderate; 3=Severe; 4=Extreme (see below). The types of tasks and specific examples of each task are described below.

Inattentive behaviors: Examples of inattentive, off-task behaviors include: attending to competing stimuli (cell phone, lip balm, etc.), looking away from the directed activity (ex. doodling), and talking to a neighbor. Inattentive behaviors were rated based on time spent distracted. Raters used a set criteria to log inattentive behaviors: intermittent mild inattention

(none [0]) happening 1 time per 5 minutes; consistent inattention (mild [1]) happening less than 50% of the time; impairing only to self and consistent inattention (moderate [2]) happening 50 to 75% of the time; impairing to self and consistent inattention happening 75 to 100% of the time or impeding the attention of others (severe [3]); and an extreme behavior or consistent inattention (extreme [4]) happening 100% of the time.

Hyperactive behaviors: Examples of hyperactive behaviors included fidgeting, interrupting others, being talkative, being impatient, and behaving as if excessively driven. Raters also used a set of criteria to document hyperactive behaviors: intermittent mild movements (none [0]) happening 1 time per 5 minutes; impairing only to self and consistent small controlled movements (mild [1]) happening less than 50% of the time; impairing only to self and consistent small controlled movements (moderate [2]) happening 50 to 75% of the time; consistent movement impairing to self happening 75 to 100% of the time or impairing to others (severe [3]); and an extreme behavior and self impairing consistent behavior (extreme [4]) happening 75 to 100% of the time.

2.4.2. Observer ratings during unstructured period—During the unstructured sections, raters alternated walking around the room at five-minute intervals to record the participants' behaviors. Raters noted whether the participant was working on a required task or an unrequired task. Raters also noted whether the participant was exhibiting significant inattentive or hyperactive behaviors, such talking on a cell phone in the room or leaving the room. The unstructured sections were significantly different from the structured tasks because they required participants to work independently. Ratings were performed after participants completed the logic task. The logic task was not included because the nature of working in a group work may be more engaging, and does not demonstrate an individual's typical focus for tasks. A separate peer rating scale captures participants' inattention for this activity.

Inattention: Raters based their ratings on the amount of time participants spent attending to tasks; greater than 90% of the time spent on required tasks (none [0]); 81 to 90% of time spent on required task (mild [1]); 71 to 80% of time spent on required tasks (moderate [2]); and 61 to 70% of time spent on required tasks (severe [3]); and less than 60% of time spent on required tasks (extreme [4]).

Hyperactivity: Raters based hyperactive ratings on the amount of time participants spent out of the room; out of the room for less than 10 minutes (none [0]); out of the room 1 time for more than 10 minutes (mild [1]); out of the room 2 times for a total of 10 to 15 minutes (moderate [2]); out of the room 3 times or 2 times totaling 15 minutes of more (severe [3]); and out of the room 4 times or more than 50% of the time (extreme [4]). The time a participant spent out of the room after completing all the required tasks was not counted.

2.4.3. Final scores—We used the observer-rating inventory (ORI) rating system as a way of measuring the frequency of hyperactive or inattentive actions and then multiplied it by the intensity of those actions, which was also determined from the ORI system. Each rater wrote down every single action or behavior that was made by a participant during any given task (except for the unstructured periods). These behaviors were specified as either hyperactive, inattentive, or both. Each separate movement or action that a rater recorded was given a frequency of "1." If a rater recorded actions in times rather than frequencies, then the total time was divided by 10 seconds in order to determine a frequency. Intensity was determined to be the score (none-extreme) that was given to each participant for each task. They were given a final score for each task in both the hyperactive and the inattentive categories. These scores took into account the severity/intensity of a movement or action, and the amount of

movement in an allotted time period. For example, getting up and walking around during a 5 minute task would be considered more extreme, or more “intense” than getting up and walking around during a 25-minute task. Each rater overlapped with second observer for reliability assessment. Any differences were reviewed with the project director and verified through the videotape. We multiplied the frequency of actions by the intensity of those actions to come up with a final rating. In order to be sure that each frequency was properly represented in the final score, intensity scores were all increased by 1 point, making the *none-extreme* scale range from 1-5 rather than 0-4. This was done strictly for the purposes of multiplication. This *frequency X intensity* score gives us a better picture of how much more inattentive or hyperactive one participant was in comparison to another.

2.5. Statistical analysis

To evaluate the performance of ADHD relative to control participants on measures of task performance we modeled the three dependent measures (e.g., morning math, early afternoon math, late afternoon math) simultaneously with multivariate regression models with case-control status, sex, and age as the independent variables. Post estimation Wald tests of the three case-control coefficients (i.e., the test that they were jointly equal to zero) were used for hypothesis testing. ADHD versus control comparisons on ADHD symptom severity (self ratings, trained observer ratings, and peer ratings) were made with t-tests at each period of assessment. All statistical tests were two-sided and statistical significance was determined at $P < 0.05$.

3. Results

One hundred nineteen participants took part in the study (56 ADHD and 63 non-ADHD control participants). There were no statistically significant differences in age or sex between the ADHD and control groups, respectively, but ADHD participants had significantly lower Global Assessment of Functioning ratings (Table 2). Additionally significant differences were found on the Endicott Work Productivity Scale (Endicott and Nee, 1997).

As shown in Table 3, ADHD participants demonstrated poor performance throughout the day on the math fluency, and editing text for spelling, punctuation, and grammar.

The profile of symptomatic ratings according to participant self-report (Figure 1) and trained research observers (Figure 2) are presented for the full day and broken down into segments: morning, afternoon, and late afternoon. Each task administered is presented across the X-axis according to the work simulation day schedule. Self-ratings of ADHD symptoms showed substantial discrimination between groups: ADHD participants reported statistically significantly elevated ADHD symptoms during each of the simulation periods (morning, afternoon, late afternoon) and during each of the simulation tasks (video comprehension, math, lecture, reading comprehension, text editing, and unstructured time) (Figure 1). In contrast, trained research staff observers rated ADHD participants as more impaired during the morning, afternoon, and late afternoon video comprehension and text editing tasks only (Figure 2).

4. Discussion

The main goal of this study was to examine workplace performance deficits in adults with ADHD as they occur across the day in a simulated workplace laboratory environment. Participants with ADHD consistently self reported statistically significantly elevated ratings of symptoms of ADHD across every task and within every time period on the simulation when contrasted with non-ADHD controls. Task performance was found to be deficient in a

small number of areas and there were few statistically significant differences identified by observer ratings. Symptoms reported by participants with ADHD in the simulation including internal restlessness, intolerance of boredom and difficulty maintaining vigilance were significant and could adversely impact workplace performance over the long-term.

These findings in a large sample of adults with ADHD expand upon earlier work by our group, and support the utility of a work simulation laboratory paradigm to assess symptoms of ADHD and workplace deficits in adults with ADHD.

The finding that self-ratings of ADHD symptoms by participants with ADHD were statistically significantly elevated throughout the 10-hour day underscores the struggle that individuals with ADHD face in the workplace with their ADHD symptoms. ADHD participants reported significant internal feelings of symptoms of ADHD including restlessness and feeling like they needed to move, despite very limited observations by raters of those symptoms. The self-ratings by our participants were immediately following a particular activity in the workplace and thus very close to the time where the participant experienced the feelings. These findings provide further support for the utility of self-reports as a method of getting clinically useful information from individuals with ADHD. Multiple studies have supported the validity of self-reported ADHD symptoms in adults including studies of non-referred adult relatives of ADHD children (Biederman et al., 1990), clinically-referred ADHD adults (Biederman et al., 1993; Millstein et al., 1997), surveys of college students (Heiligenstein and Keeling, 1995; Heiligenstein et al., 1998; Heiligenstein et al., 1999), participants in treatment protocols (Spencer et al., 1995), and adults from the general population selected for extreme responses on an ADHD rating scale (Murphy and Barkley, 1996).

In contrast, there were few statistically significant differences in observer ratings of ADHD symptoms during most periods of the day. Although the participative experience of “problems trying to sit still” was present across most tasks, in this laboratory setting, participants were able to hide their movements to a point that they were not generally visible to observers thus there were no statistically significant differences in observable measures of hyperactivity in adults with ADHD versus controls. This finding suggests that although adults may appear calm on the outside, they continue to suffer from internal restlessness. This finding is consistent with the literature that documents that observable hyperactivity is much less apparent in adults with ADHD than in children (Weiss et al., 1985; Gentile et al., 2006). The internal feeling of restlessness can be related to a sense of internal turmoil and cause adults with ADHD to be less able to successfully complete activities in the workplace, especially those activities that might not be stimulating to them (Barkley et al., 1996; Kessler et al., 2010). Although these findings suggest that for limited periods of time, such as under scrutiny, adults with ADHD can successfully mask these symptoms, struggling with a competing urge to move while attempting to complete a task can be expected to lead to poor performance and job failure over the long term.

Despite the finding that participants were able to “hide” their inattentive and hyperactive symptoms, on many of the work related tasks assessed, there were significant observable differences between participants with ADHD and controls on the video task, which required the most vigilance. The video task was specifically designed to tax the participants’ ability to maintain sustained attention for a lengthy period of time. The Continuous Performance Task (CPT) was designed for this same purpose and has consistently separated individuals with ADHD from controls (Barkley et al., 2001; Epstein et al., 2001).

The task that was most significantly impaired in participants with ADHD than in controls through all three periods of the day was the Math Fluency task. As found in the literature

(Sostek et al., 1980; Riccio et al., 2002), working on a routine task under timed conditions is difficult for individuals with ADHD. Additionally, there were statistically significant differences found on the editing tasks administered between participants with ADHD and Controls. The editing tasks require a high level of attention to detail because embedded within a passage there were errors of spelling, punctuation and grammar. These findings indicate that completing routine tasks under timed conditions and attending to detail are key weaknesses for individuals with ADHD that could have a major impact in workplace performance.

Performance on tasks within the unstructured period were less discriminating, in part, because that aspect of the simulation was designed to assess whether tasks were completed without explicit direction or left incomplete. The nature of the tasks was less sensitive to ADHD symptoms, in that they were untimed.

Taken together, these findings are consistent with reports from ADHD individuals and their employers that ADHD impairs work performance. Not only are these findings relevant to adults with ADHD and the clinicians who work with them, but this information could also be useful in vocational planning and appropriate accommodations for individuals with ADHD. Considering the fundamental importance of adequate workplace performance for societal functioning, these findings support efforts aimed at developing approaches to help remedying them. Future research could benefit from testing workplace performance in treatment studies of adults with ADHD.

Strengths of this study include a well-characterized group of untreated adults with ADHD, and measurement of variables salient to workplace function.

The study however had some limitations as well. We did not adjust for multiple comparisons thus due to the number of comparisons, there may have been some type I errors. We did not stratify by subtypes of ADHD because the numbers in each group were not large enough for analysis. Although designed to be analogous to a real-world work setting, our paradigm is not necessarily representative of all types of work and was performed in a limited period of time (one day). In addition, participants were aware that they were taking part in an observational study of work and ADHD and this knowledge may have impacted their behaviors and performance. Additionally, our sample consisted of relatively young, mainly Caucasian adults and may not generalize to the general population or to other ethnic groups. Lastly, because of the large number of tests used, we cannot rule out the possibility of chance findings.

Despite these considerations, this study of a novel laboratory workplace simulation for adults with ADHD documented significant workplace deficits in this population relative to an age and sex matched group of non-ADHD individuals. Our results support the validity and utility of this novel workplace paradigm that could be used in future intervention studies aimed at improving workplace deficits in adults with ADHD.

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Reed Medical Education (a logistics collaborator for the MGH Psychiatry Academy). Commercial entities supporting the MGH Psychiatry Academy are listed on the Academy's Web site, www.mghcme.org.

In the past 2 years, Dr. Hammerness has participated in CME activities/professional talks supported by Ortho-McNeil Janssen and Shire and served on the advisory board for Shire. In the past 2 years, Dr. Hammerness has participated, as an investigator/principal investigator, in research studies funded by the following pharmaceutical companies/companies: Cephalon, Eli Lilly, Elminda Ltd, GlaxoSmithKline, Johnson & Johnson, McNeil, Merck, New River, Novartis, Ortho-McNeil Janssen, Pfizer, Shire, Takeda. Dr. Hammerness has also received honoraria from commercial entities supporting the MGH Psychiatry Academy, www.mghcme.org.

In the past year, Dr. Faraone received consulting fees and was on Advisory Boards for Shire Development and received research support from Shire and the National Institutes of Health (NIH). In previous years, he received consulting fees or was on Advisory Boards or participated in continuing medical education programs sponsored by: Shire, McNeil, Janssen, Novartis, Pfizer and Eli Lilly. In previous years he received research support from Eli Lilly, Shire, Pfizer and the NIH. Dr. Faraone receives royalties from a book published by Guilford Press: *Straight Talk about Your Child's Mental Health*.

Dr. Joseph Biederman is currently receiving research support from the following sources: Elminda, Janssen, McNeil, and Shire. In 2011, Dr. Joseph Biederman gave a single unpaid talk for Juste Pharmaceutical Spain, received honoraria from the MGH Psychiatry Academy for a tuition-funded CME course, and received an honorarium for presenting at an international scientific conference on ADHD. He also received an honorarium from Cambridge University Press for a chapter publication. Dr. Biederman received departmental royalties from a copyrighted rating scale used for ADHD diagnoses, paid by Eli Lilly, Shire and AstraZeneca; these royalties are paid to the Department of Psychiatry at MGH. In 2010, Dr. Joseph Biederman received a speaker's fee from a single talk given at Fundación Dr. Manuel Camelo A.C. in Monterrey Mexico. Dr. Biederman provided single consultations for Shionogi Pharma Inc. and Cipher Pharmaceuticals Inc.; the honoraria for these consultations were paid to the Department of Psychiatry at the MGH. Dr. Biederman received honoraria from the MGH Psychiatry Academy for a tuition-funded CME course. In 2009, Dr. Joseph Biederman received a speaker's fee from the following sources: Fundacion Areces (Spain), Medice Pharmaceuticals (Germany) and the Spanish Child Psychiatry Association.

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Figure 1.

(A) Self-Rating by Subjects of Internal Feelings of Mental Restlessness and Inattention; (B) Self-Rating by Subjects of Internal Feelings of Physical Restlessness and Hyperactivity.

Figure 2.

(A) Observer Blinded Ratings of Subjects' Symptoms of Inattention; (B) Observer Blinded Ratings of Subjects' Symptoms of Hyperactivity.

Table 1

Structure of Workplace Simulation Day

Time	Tasks
8:00 a.m. – 8:30 a.m.	Orientation
8:30 a.m. – 10:00 a.m.	Period 1: Structured Tasks
10:00 a.m. – 11:30 a.m.	Period 1: Unstructured Tasks
11:30 a.m. – 12:15 p.m.	Lunch Break
12:15 p.m. – 1:45 p.m.	Period 2: Structured Tasks
1:45 p.m. – 3:15 p.m.	Period 2: Unstructured Tasks
3:15 p.m. – 3:30 p.m.	Break
3:30 p.m. – 5:00 p.m.	Period 3: Structured Tasks
5:00 p.m. – 6:30 p.m.	Period 3: Unstructured Tasks

Table 2

Characteristics of ADHD subjects and Controls.

	ADHD (N=56)	Controls (N =63)	Test statistic	P-value
	Mean $\pm$ SD or N (%)	Mean $\pm$ SD or N (%)		
Age	28.3 $\pm$ 8.5	30.8 $\pm$ 10.2	$t_{(113)}=-1.40$	0.16
Sex	29 (54)	25 (41)	$\chi^2_{(1)}=1.86$	0.17
Socioeconomic status	2.2 $\pm$ 1.2	2.2 $\pm$ 0.9	$z=-0.48$	0.63
Mean number of ADHD symptoms	8.2 $\pm$ 0.9	0.6+/-1.4	9.52	p<0.001
Global Assessment of Functioning	61.0 $\pm$ 4.8	70.5 $\pm$ 2.2	$t_{(113)}=-13.76$	<0.001
IQ	114.6 $\pm$ 10.8	118.4 $\pm$ 9.8	$t_{(111)}=-1.92$	0.06
Endicott Work Productivity Scale	42.4 $\pm$ 17.4	11.5 $\pm$ 10.4	$t_{(99)}=11.10$	<0.001
Number of jobs per year after completed education	0.82 $\pm$ 0.99	0.63 $\pm$ 0.69	$z=0.82$	0.41

Table 3

Task Performance Throughout the Day in ADHD and Control Subjects

	ADHD (N=56)				Controls (N=63)				F	p-value
	Morning	Early Afternoon	Late Afternoon	Morning	Early Afternoon	Late Afternoon				
Structured Tasks										
Video	2.4±1.5	0.7±1.0	2.0±1.0	2.1±1.6	0.6±0.8	2.0±1.1	2.9	4	0.03	7
Math Fluency	122.1±27 3	103.8±38	118.5±39	132.9±28	133.4±227	146.1±19	4.6	3	0.00	4
Lecture	3.8±1.1	3.6±1.2	4.4±0.8	3.7±1.2	4.0±0.9	4.3±0.8	2.4	4	0.06	8
Reading Implicit	3.0±1.2	4.3±0.9	2.8±1.2	3.2±1.0	4.2±0.9	3.0±1.2	0.5	5	0.65	1
Reading Explicit	3.75±1.1	3.8±1.2	3.6±1.3	4.1±0.9	3.9±1.0	3.9±1.1	1.0	1	0.37	9
Editing Spelling	3.4±1.1	2.9±1.3	2.3±1.2	3.6±1.1	2.9±1.2	3.0±1.3	2.8	4	0.04	1
Editing Punctuation	2.6±1.3	2.9±1.2	3.1±1.3	3.2±1.3	3.5±1.2	3.6±1.3	3.2	7	0.02	7
Editing Grammar	3.6±1.4	3.1±1.6	3.3±1.5	3.9±1.1	3.7±1.4	4.2±1.1	5.6	5	0.00	5
Unstructured Tasks										
e-mail	5.3±1.0	5.4±0.9	5.4±0.8	5.3±1.1	5.2±1.1	5.5±0.9	0.8	3	0.48	
Product Order	11.4±2.9	12.6±2.5	11.8±3.3	11.1±3.7	12.3±3.1	12.7±2.8	0.8	9	0.45	2
Reading Implicit	3.2±1.2	3.0±1.2	3.3±1.3	3.3±1.1	3.2±1.1	3.3±1.2	0.3	4	0.79	5
Reading Explicit	3.6±1.1	4.0±1.1	4.1±1.2	4.0±0.8	4.1±1.0	4.3±0.9	1.1	7	0.34	
Writing Spelling	1.4±1.6	1.1±1.7	1.8±2.0	0.9±1.1	1.0±1.5	1.0±1.3	3.0	5	0.03	4
Writing Punctuation	1.7±1.8	1.7±2.1	1.1±1.5	1.2±1.7	1.5±2.3	2.3±3.7	0.9	9	0.40	1

ADHD (N=56)				Controls (N=63)				
	Morning	Early Afternoon n	Late Afternoon	Morning	Early Afternoon n	Late Afternoon	F	p-value
Writing Organization	5.7±1.5	5.6±1.7	4.7±2.0	6.6±2.1	6.1±1.6	4.5±2.0	2	0.121
Writing Theme	3.4±0.9	3.4±0.9	3.7±0.5	3.5±0.8	3.6±0.6	3.6±0.8	1.84	0.148