Long-Term Episodic Memory in Children with Attention-Deficit/Hyperactivity Disorder

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Twenty-nine grade-matched 4th–8th-grade males, 12 with attention-deficit/hyperactivity disorder (ADHD) (age $M = 12.2$ years, $SD = 1.48$), and 17 without (age $M = 11.5$, $SD = 1.59$), completed two working memory tasks (digit span and the Simon game) and three long-term episodic memory tasks (a personal event memory task, story memory task, and picture recognition task). In line with clinical observations, children with ADHD performed worse than peers on all working memory tasks, but performed as well as or better than peers on long-term episodic tasks, demonstrating particularly detailed memory for personally experienced past events. Participants' parents also completed questionnaires about their children's memories in daily life. Parents rated children with ADHD lower than children without ADHD on working and semantic memory (e.g., remembering names, spelling, and math), but rated them as high or higher on memory for events. Implications for theory and educational practice are discussed.

Attention-deficit/hyperactivity disorder (ADHD) is one of the most prevalent disorders diagnosed among American children. The primary characteristics of ADHD include developmentally inappropriate levels of inattention, hyperactivity, and impulse control that may affect both cognition and behavior. Estimates suggest that ADHD affects between 3 percent and 16 percent of school-age children in America, or one to two children in every classroom, and boys are more likely than girls to receive the diagnosis (American Academy of Pediatrics, 2000; American Psychiatric Association, 1994; Scahill & Schwab-Stone, 2000; U.S. Department of Health and Human Services, 1999). ADHD significantly impacts children's daily lives, feelings, and relationships and it often has detrimental effects on academic performance (Levine, 2002).

Clinical observers have noted that alongside problems with inattention and behavioral control, children with ADHD often suffer from significant memory failure (American Psychiatric Association, 1994; Levine, 2002). Researchers have confirmed this, documenting memory deficits among children and adults with ADHD on a range of tasks (e.g., August, 1987; Berlin, Bohlin, Nyberg, & Janois, 2004; Sergeant, Oosterlaan, & Van der Meere, 1999). Notably, most of these tasks have focused on relatively short-term memory for stimuli and facts that are primarily important in the laboratory context and less relevant to children's daily lives. For example, when they are given tests of digit span or are asked to recall select mathematical facts or remember items on a list after brief intervals, children with ADHD

typically underperform. Although ADHD is often comorbid with other psychiatric diagnoses, studies indicate that such reported memory problems are a function of the ADHD diagnosis alone (e.g., Klorman et al., 1999; Murphy, Barkley, & Bush, 2001; Nigg, Hinshaw, Carte, & Treuting, 1998). Clearly, problems with memory may contribute to the difficulties children with ADHD face in school settings. As Levine (2002) intoned, "A child may be able to understand a fact, process, or concept as it is being explained or demonstrated; but without memory, none of it can be retrieved and applied. Without the collaboration of the proper memory functions, learning fails" (p. 91).

Although memory deficits are common and well documented among children with ADHD, clinical observations also point to some surprising memory competencies among these children. For example, a perplexed mother whose 17-year-old son performed poorly on school tests commented that, when it came to remembering real-life episodes, her son excelled:

> I have no idea why my Vance is failing in school. He has the best memory of anyone in our family...We might go to a restaurant where we haven't been for several years. He remembers where we parked and can even recall what he ate and where the men's room was. But that kid can't ever remember his vocabulary or spelling words from last night (Levine, 2002, p. 115).

Based on his work as a pediatrician, Levine (2002) noted that parents and practitioners working with children with ADHD regularly make similar observations, describing a puzzling disjunction between children's poor memory performance in school settings and their excellent memory for the distinctive events of their lives.

Why might such a disjunction exist? Basic research on memory has suggested fundamental distinctions between short-term or working memory and long-term memory tasks, and between semantic and episodic memory processes (Tulving, 1993). These distinctions may help clarify how children with ADHD could perform very differently on school and personal-event memory tasks.

Working memory is reflected on tasks that require children to hold information in mind and then reproduce it after brief periods of a few seconds to at most several minutes. Most memory research that has included populations of participants with ADHD has focused on working memory. Many studies have reported impoverished performance on working memory tasks among both children and adults with the disorder (e.g., August, 1987; Marzocchi, Lucangeli, De Meo, Fini, & Cornoldi, 2002; Murphy et al., 2001; O'Neill & Douglas, 1996; Tannock, Purvis, & Schachar, 1993; Vassileva et al., 2001; Voelker, Carter, Sprague, Gdowski, & Lachar, 1989). Indeed, Barkley's (1997) review of empirical studies contrasting the performance of children with and without ADHD on primarily working memory tasks suggested that, on the majority of tasks in the literature, children with ADHD performed significantly worse than their peers. For example, children with ADHD typically do poorly when they are presented with information such as lists of words or numbers and are tested after a brief time interval. Children with ADHD also have difficulty imitating long sequences of goal-oriented behavior, such as when they are asked to reproduce a pattern of sounds and lights immediately following presentation in the game Simon (Murphy et al., 2001). It appears challenging for these children to hold in mind both the to-be-imitated sequence and a representation of how to execute the behavior (Barkley, 1997).

Semantic memory refers broadly to memory for general world knowledge and includes stored information about routine activities, acquired facts, and academic subjects. Such knowledge is typically characterized as highly organized, verbally accessible, and largely independent of the specific contexts in which it was acquired (Tulving, 1972). Most aptitude tests, IQ tests, and school tests draw extensively on semantic memory. Semantic memory impairments among children with ADHD have been well documented in both the clinical and research literature (e.g., Barkley, 1997; Paule et al., 2000). Failure of semantic memory is typified by the difficulty children with ADHD often have in recalling general information in school settings such as spelling words or math concepts.

In contrast to semantic memory, episodic memory refers to memory for information acquired and associated with a single specific moment in time (Tulving, 1972). It includes, for example, recognition of which items were previously seen on a particular list or memory for details that were present in a single past telling of a story. Importantly, episodic memory also includes memory for personally experienced life events, illustrated by Vance's recollection, described earlier, of the details of a long-past family visit to a restaurant (Levine, 2002; Pillemer, 1998). Because an episodic memory is by definition associated with a particular, unique past experience, recollection typically includes some information about context (e.g., the places, emotions, actions, and timing associated with that experience). Tests of episodic memory require individuals to recall information acquired at a single point in time in the past after short or long delays. Tests of short-term episodic memory include those that prompt children to recall numbers, symbols, or story content after brief intervals and include many standard laboratory working memory tasks. Tests of long-term episodic memory include those that assess memory for similar stimuli after long delays. Only a handful of studies have examined this kind of long-term memory functioning among children with ADHD (e.g., Kaplan, Dewey, Crawford, & Fisher, 1998; Lorch et al., 1999; Mealer, Morgan, & Luscomb, 1996; Webster, Hall, Brown, & Bolen, 1996). Tests of long-term memory also include those that assess recall of personally experienced life events (e.g., a particular school field trip). Evidently, it is these long-term, personally relevant episodic tasks that clinical evidence suggests should be the strength of children with ADHD. In Levine's words, "it is especially common to find phenomenal episodic memory among children with weak attentional controls" (Levine, 2002, p. 115).

Despite such claims in the clinical literature, no published study to date has examined long-term memory for personally experienced past events among children with ADHD. Considering the nature of ADHD more broadly helps make sense of why children with the disorder may do better on long-term episodic memory tasks than on shorter-term and semantic tasks and why they may sometimes appear to have better event memory than other children.

As Barkley and colleagues have persuasively argued, the deficits in working memory that children with ADHD exhibit are part of a larger cognitive and behavioral repertoire affected by inadequacies in the executive function of the brain generally associated with prefrontal cortex (Barkley, 1997, 1999). For example, the problems with self-regulation and impulsivity that children with ADHD often exhibit may stem in part from the brain's inability to effectively curb initial or prepotent responses that are stimulated by the immediate environment. In the cognitive domain, the same principle might explain why these children have been reported to have relative difficulty with interference control, as measured by the Stroop Color-Word interference test (Barkley, 1997), problems creating impromptu strategies for organizing to-be-remembered material (August, 1987), and poor problem-solving skills (Barkley, 1997). Similarly, deficiencies in executive function are related to impairments among children with ADHD in time perception and time-sensitive behavior (e.g., calling out in class), which contributes to disorganized motor planning and execution (Barkley, 1997; Paule et al., 2000).

In the case of long-term episodic memory, disruptions in executive function may not always have the same negative consequences for performance as they do for working memory and semantic tasks. In these latter tasks, the performance of children with ADHD is likely to be jeopardized by distractibility and attention to irrelevant stimuli at encoding and by an inability to inhibit interference from incorrect responses or extraneous information at retrieval. Working memory tasks typically require children to produce a single correct set of responses, as do many semantic memory tasks that children are presented with in classroom contexts. However, the same does not hold true for many long-term episodic tasks. When children are asked to recollect the events of their lives, small

details that may have captured their attention during an event, but are not central to the event narrative, may enhance rather than detract from children's reports. The same may be true on long-term episodic tasks that prompt children to provide as many details as they can about a story. Here again, if children with ADHD attend to and report more small details than other children, this may represent a memory advantage. On some tasks, remembering details that are only tangential to the central story line may eventually assist children in retrieving central information. Importantly, on long-term episodic tasks that focus on personal-event memories or stories, the subset of information that is part of an acceptable answer is broader than it would be in the case of traditional working memory and semantic tasks.

This study focused on the provocative idea that, while children with ADHD perform relatively poorly on laboratory and school-related tasks, they may exhibit better memory on long-term episodic tasks, equaling or surpassing their peers. Despite clinical evidence, no empirical research to date has examined memory among children with and without ADHD with the broad battery of memory tasks required to evaluate whether this idea is correct. Attempts to better understand the memory profiles of children with ADHD are worthwhile because the discovery of significant memory strengths among these children could have important implications for theory and educational practice.

In this study, we administered two working memory tasks (i.e., digit span and the memory game "Simon") and three long-term episodic memory tasks (i.e., a personal event memory task, story memory task, and picture recognition task) to a sample of grade-matched male children with and without ADHD. Also in line with clinical observations and past research, we predicted that children with ADHD would do worse than their peers on working memory tasks, indexed by lower scores on the digit span task and the Simon game. In line with clinical observations, we predicted that children with ADHD would perform as well as or better than peers on long-term episodic memory tasks. Here, performance was indexed by the length and detail of personal-event narratives, the number of details recalled in the story memory task, and the number of pictures recognized on the picture recognition task.

In addition, parents of all participating children completed a questionnaire in which they evaluated their child's memory performance in a number of areas of daily life (e.g., telling jokes, working on math or reading, talking about events). The questionnaire allowed us to systematically evaluate the validity of informal reports in the literature suggesting that parents often notice their children with ADHD showing signs of memory failure in school but having better memory, even the "best memory in the family," for events.

METHOD

Participants

Twenty-nine fourth–eighth grade males participated in five memory tasks. Twelve of the participants (age $M = 12.2$, SD $= 1.48$; grade level $M = 6$) had been diagnosed with ADHD (8 with the predominately hyperactive subtype; 4 with the predominately inattentive subtype) and no other comorbid cognitive or psychological disorder prior to the study. All participants with ADHD attended a private school focused on serving children with ADHD and similar disorders, and all had received diagnoses from a pediatrician, clinical psychologist, or other professional. The remaining 17 participants had never been diagnosed with ADHD or any other type of disorder (age $M = 11.5$, $SD = 1.59$, grade level $M = 6$) and attended public school. Additionally, one parent of each participating child completed a 22-item questionnaire about his or her child's memory and diagnostic status. The sample included roughly equal numbers of participants with and without ADHD in each grade from fourth through eighth, so that the two groups were effectively matched for grade level.

Materials and Procedure

The study took place in the two schools described above and was conducted in two phases, identical in both schools. In the first phase, a packet was sent home to parents of fourth- through eighth-graders. Each packet included a letter describing the study and asking for permission to include the parent's child as a participant, an informed consent form, and a parent questionnaire. Parents who agreed to participate gave consent, filled out the questionnaire, and returned the completed forms to the researchers. Fifty-two parents completed the forms and questionnaires. Participants in the final sample were selected by first identifying all children in the private school whose parents reported they had been diagnosed with ADHD and no other comorbid disorders. Because all but two of these children were male, the final sample of children with ADHD was confined to 12 male participants. Participants without ADHD were then selected by identifying males in the same grades who had never been diagnosed with any disorder.

In the second phase of the study, researchers administered five memory tasks to each participating child during the school day on school premises. Detailed descriptions of the tasks are provided below. Each participant met individually with a hypothesis- and condition-blind researcher in a quiet room just outside their classroom in two separate testing sessions on a single school day. Each session lasted approximately 30 minutes, and the two sessions were separated by an interval of between 2 and 3 hours. During the first session with each child, researchers administered the personal event memory task and presented children with a narrated and illustrated story on a computer screen, which served as the initial presentation in the story memory task. The second session included two working memory tasks (digit span and the Simon game) and tests of recall and picture recognition for the story shown in the first session. Each session was tape recorded and later transcribed and coded for analysis. Descriptions of the materials, testing procedures, and coding schemes for the parent questionnaire and each of the five memory tasks are provided below.

Parent Questionnaire

The parent questionnaire, created specifically for this study, assessed how responding parents viewed their children's memory abilities. Parents responded to a set of memory assessment questions using a five-point Likert-type scale. Questions focused on the following: (1) how good the child was at telling stories about experiences; (2) the amount of detail the child was likely to include in a story; (3) how often the child included details of an experience that no one else seemed to remember and recalled small details of an experience; (4) how well the child was able to tell jokes (and how often the child forgot parts of a joke or told a joke in the wrong order); (5) how well the child recalled information when doing schoolwork (including math, spelling, geography, history, and science, rated separately); (6) whether the parent believed the child was the best in the family at remembering events and factual information in general and specific domains; (7) whether or not the child often got frustrated when other people could not recall the same details as they could; and (8) how well the child remembered words in songs, remembered people's names, and matched names with faces. The questionnaire also posed yes/no questions related to the child's diagnostic category, including whether or not the child had been diagnosed with ADHD, and if so, whether the child was receiving any treatments (i.e., medications or behavior therapy) and whether the child had a comorbid learning disability or other disorder. The questionnaire also asked whether the child had difficulties in school and whether the child had attended special education classes or received other special assistance in school. The questionnaire took approximately 15 minutes to complete.

Digit Span

The digit span task was taken directly from the Wechsler Intelligence Scale for Children–Third Edition (WISC-III; Wechsler, 1991) and consisted of two separately scored parts: digit span forward and digit span backward. In digit span forward, the researcher read aloud number strings to the child at a rate of one number per second. The child then repeated the numbers back in the same numerical sequence as he heard them. The first level began with two trials of two number strings (e.g., 2–9 and 4–6). The child was given longer strings after successfully repeating at least one string in a level. The testing ended when the child was unable to successfully repeat back any string in a level. In digit span backward, the task was the same except that the child repeated the numbers that he or she heard in reverse, or backward, order. For every successful repetition of a sequence the child received a score of 1, for a total score per level of 2. If a child did not successfully repeat a sequence, he received a score of 0. The sum of all completed strings within each part made up the score for that part; the sum of the scores for each part made up the total digit span score.

The Simon Game

The Simon game is a widely recognized test of working memory. The Simon game is made by Hasbro^{TM} for 7-year-olds through adults and is available commercially. The game is made up of four large colored keys in a yellow plastic base. The colors of the four keys are blue, green, red, and yellow and each key emits a different tone when pressed. The object of the game is for the player to repeat increasingly longer color/tone patterns that the game provides. The game typically begins by displaying a pattern of just one tone and one lit key, and with each successful repetition, the game then displays a longer and more complex pattern for the individual to repeat.

Before playing the game, each child was asked if he was familiar with the game and, regardless of familiarity, was read a standard set of directions. After listening to the directions, each child completed one practice trial. A score for each trial was calculated by recording the number of key presses in the longest pattern the child correctly reproduced. Each child was given three trials and the best score was used for data analysis.

Personal-Event Memory Task

The personal-event memory task consisted of two questions, modeled after Han, Leichtman, and Wang (1998), designed to elicit children's narrative memory reports. Researchers told each child, "I have never met you before and would like to find out all about you. I'd like to ask you about memories of things you've done." They then posed the following open-ended questions: "Do you remember your first day of school this year? Tell me everything you remember from your first day of school this year," and "Now I am going to ask you to think back. Can you tell me something special that happened to you recently? Imagine yourself there and tell me everything that happened." To encourage children to provide as much information as possible, researchers used the following standard prompt after each question: "What else happened? Anything else? Think real hard and tell me everything you can remember."

Each answer was recorded, transcribed, and analyzed for multiple components. The coding was similar to the coding scheme used in previous studies of other populations (e.g., Han et al., 1998; Leichtman, Pillemer, Wang, Koreishi, & Han, 2000). Narratives were coded for length (i.e., words and sentences), details (i.e., descriptives, including adverbs, adjectives, modifiers, and time statements), specific dialogue (i.e., reported or not), and specificity of narrative (i.e., whether or not the narrative referred to a specific moment in time, as opposed to routine or multiple events, like an event last Saturday). Three trained hypothesis- and condition-blind research assistants coded all of the narratives. Thirty percent of the narratives were randomly chosen and independently coded by the head researcher in order to assess reliability. Agreement between the raters ranged from 94 percent to 100 percent. Disagreements were collaboratively reviewed and settled by the head researcher.

Story Memory Task

The story memory task was created specifically for this study and was intended to assess long-term episodic, nonpersonal-event memory (see Appendix A). The task consisted of each

child viewing 10 novel stories, which contained both narration and pictures, and then answering questions about different aspects of each story after a 2- to 3-hour delay. The stories were presented via computer and each lasted approximately 1 minute. There was a 5-second delay between each story.

Each story introduced a fictitious person, described an activity or object that the person liked, and presented a narrative related to that activity or object. Each story contained "central" details, defined as plot-relevant details related to the fictitious person and events (e.g., the gender, age, likes of the person). Each story also contained "peripheral" details, defined as details of the story that did not change the composition or plot. (See Appendix A for examples.)

Along with each story narration, six "central" photographic pictures were presented in the center of the computer screen as the story unfolded. Central pictures were defined as those that corresponded with a critical part of the narrated story line (e.g., a picture of a fictitious person's face, a picture of an object the person liked). (See Appendix A for examples.)

Three of the central pictures were presented alone on the screen, and three were presented surrounded by four "peripheral" pictures, one in each corner of the screen. Peripheral pictures were irrelevant to the narrative, unrelated to the person and ideas in the story, and never mentioned (e.g., a picture of an egg beater accompanying a story about a bicycle and a central picture of a bicycle). Each story was the same length and contained the same number of central and peripheral details (7 each) and central (6) and peripheral (12) pictures. This task was episodic because the stories were completely new to the child and memory was based on a one-time experience in which the child did not have the opportunity to study and overlearn the stories.

Recall of the stories was probed sequentially for each of the 10 stories. (See Appendix A for examples.) For each story, the child was first shown a picture of the main character on the computer screen (the same picture that had been presented originally) and was then provided with the name of the character and asked to tell about him or her (e.g., "This is Jimmy. Tell me everything you remember about him."). After the child replied, the computer screen went blank and the child was asked four direct questions, two about central details and two about peripheral details in each story. Responses were recorded by the researcher on paper and audiotape. Each correct answer was scored as a "1." Thus, for each of the stories, children could receive a maximum score of 2 for correct answers to central questions (or a total score of 20) and a maximum score of 2 for correct answers to peripheral questions (or a maximum score of 20).

Picture Recognition

The picture recognition task followed the story recall task and took place in two parts. First, the child was shown a series of 10 central pictures from the stories, all of which had been surrounded by peripheral pictures when they were originally shown. While viewing each picture, the child was asked, "Do you recognize this picture? What is it?" The child was then asked, "Do you remember any of the pictures that were around this one in the corners of the screen?" In the second part of

the recognition task, the child was shown 60 pictures on a computer screen, one at a time and in random order; thirty of the pictures had been presented previously as peripheral pictures in 1 of the 10 stories, while 30 were similar pictures of objects that had not been presented in any of the stories. The child was instructed to simply answer "yes" if he recognized seeing the picture in a corner of the screen during any of the stories and "no" if he did not recognize the picture. The child's responses to each picture were written down and coded. Scores were calculated for the total number of times the child said yes or no to recognizing pictures and the percentage of responses that were correct.

DATA ANALYSES

Independent samples t tests were used throughout the analyses to compare the means of participants with and without ADHD in terms of parent ratings and children's memory performance. Where appropriate, regression analyses were also conducted to evaluate the independent contributions of group (i.e., with and without ADHD) and age to memory outcomes. Results of analyses conducted on parent questionnaire data and data from each memory task are presented separately below.

Parent Questionnaire

A separate t test for the difference between groups was run on each memory assessment variable in the parent questionnaire. A standard linear multiple regression was also performed to see how well scores on each memory assessment variable could be predicted from group and age. The means and standard deviations for parent ratings of children with and without ADHD, as well as the sr^2 and β from the regression analyses, are presented in Table 1. The results indicated no significant difference between groups on the following variables: ability to tell stories of experiences; amount of detail included in a story; memory for geography, history, and science information; memory for general and specific factual information

TABLE 1
Means, Standard Deviations (SD), sr^2, and β (Covariate = Age) for Parental Questionnaire Responses

| Variable (Question No.) | ADHD (n = 12) | | Non-ADHD (n = 17) | | sr^2 | β |
	Mean	SD	Mean	SD		
Good at telling jokes (No. 5)**	2.58	1.16	3.47	.72	.23	.49
Forget parts of joke (No. 6)*	3.00	.95	2.23	.66	.18	−.44
Joke in wrong order (No. 7)**	2.75	.87	1.82	.73	.22	−.48
Spelling memory (No. 8a)**	2.58	1.31	3.82	.88	.20	.47
Math memory (No. 8c)*	3.17	1.27	4.12	1.11	.14	.38
Details of past experiences (compared to family) (No. 10a)[a]	3.92	.90	3.29	.77	.11	−.35
Memory for people's names (No. 13)*	2.92	1.31	3.76	.83	.16	.41

Note. Mean difference significant at: [a]$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

compared to family; tendency to become upset when others do not recall the same details from an experience; and children's ability to remember songs and faces. Analyses that revealed significant differences between groups are described below.

Ability to Tell Jokes

t tests indicated that parents rated children with ADHD as significantly worse than children without ADHD at telling jokes, more likely to forget parts of a joke, and more likely to tell jokes in the wrong order (see Table 1). Regression analyses including group and age as predictors revealed that only group made a statistically significant contribution to these effects. For group, the sr^2 for the ability to tell jokes was .227, $t(27) = 2.78$, $p = .010$ with $\beta = .489$, the sr^2 for forgetting parts of jokes was .179, $t(27) = -2.41$, $p = .024$ with $\beta = -.435$, and the sr^2 for telling jokes in the wrong order was .219, $t(27) = -2.82$, $p = .009$ with $\beta = -.482$.

Memory for Math and Spelling

t tests indicated that parents rated children with ADHD as significantly worse than children without ADHD at remembering spelling and math (see Table 1). Regression analyses including group and age as predictors revealed that only group made a statistically significant contribution to these effects. For group, the sr^2 for spelling memory was .204, $t(27) = 2.73$, $p = .011$ with $\beta = .465$ and the sr^2 for math memory was .135, $t(27) = 2.03$, $p = .050$ with $\beta = .379$.

Memory for Names

t tests indicated that parents rated children with ADHD as significantly worse than children without ADHD at remembering people's names (see Table 1). Regression analyses including group and age as predictors revealed that only group made a statistically significant contribution. The sr^2 was .161, $t(27) = 2.23$, $p = .034$ with $\beta = .412$.

Memory Compared to the Rest of the Family

t tests indicated that parents rated children with ADHD as having significantly better memory in relation to their family than children without ADHD for specific details of past experience, $t(27) = 1.99$, $p = .05$ (see Table 1). A regression analysis revealed that the contribution of group was marginally significant when age was included as a covariate. For group, the sr^2 was .114, $t(27) = -1.85$, $p = .075$ with $\beta = -.349$.

To summarize, the results of the parent questionnaire were all supportive of the initial hypothesis direction. Children with ADHD were rated significantly worse than children without ADHD on a number of semantic and school-related memory abilities, including the ability to remember spelling and math, the ability to remember people's names, and the ability to tell jokes. Children with ADHD were rated as hav-

ing a greater tendency to forget parts of jokes and tell jokes in the wrong order. In contrast, children with ADHD were rated as better than children without ADHD at remembering specific details of past experiences when compared with the rest of the family. The variance explained by the unique contribution of group ranged from 11 percent to 23 percent across the analyses.

Working Memory

Like the parent questionnaire data, scores on the working memory tasks were submitted to t tests and regression analyses including group and age as predictors. The mean scores and standard deviations for children with and without ADHD on all working memory tasks, as well as sr^2 and β values, are presented in Table 2.

Digit Span

Children with ADHD performed significantly worse than children without ADHD on the digit span task. Regression analyses including group and age as predictors revealed that only group made a statistically significant contribution to digit span scores. For group, the sr^2 for Digit Span-Forward was .139, $t(27) = 2.11$, $p = .045$ with $\beta = .383$, the sr^2 for Digit Span-Backward was .233, $t(27) = 2.83$, $p = .009$ with $\beta = .496$, and the sr^2 for the total digit span score was .223, $t(27) = 2.19$, $p = .010$ with $\beta = .486$.

Simon Game

Children with ADHD performed significantly worse than children without ADHD on the Simon game. Regression analyses including group and age as predictors revealed that only group made a statistically significant contribution to Simon game scores. For group, the sr^2 was .214, $t(27) = 2.67$, $p = .013$ with $\beta = .476$.

To summarize, the results for working memory tasks were in the hypothesized direction. As Table 2 illustrates, independent of age, children with ADHD showed significant impairments on these tasks. The amount of variance explained by group ranged from approximately 13 percent to 23 percent.

TABLE 2
Means, Standard Deviations (*SD*), sr², and β (Covariate = Age) for All Working Memory Scores

Variable	ADHD (n = 12)		Non-ADHD (n = 17)		sr²	β
	Mean	SD	Mean	SD		
Digit span-forward*	7.92	1.78	9.24	2.19	.14	.38
Digit span-backward**	3.83	1.03	5.59	2.18	.23	.49
Digit span-total**	11.75	1.96	14.82	4.11	.22	.49
Simon*	8.00	2.80	11.05	3.17	.21	.48

Note. Mean difference significant at: [a]$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

TABLE 3
Means and Standard Deviations (*SD*), sr^2, and β (Covariate = Age)
for Components of the Personal-Event Narratives
(SE = Special-Event Narrative)

Variable	ADHD (n = 12) Mean	SD	Non-ADHD (n = 17) Mean	SD	sr^2	β
Total no. of words in SE*	245.42	227.17	89.12	58.71	.18	−.44
Total no. of sentences in SE[a]	13.50	10.04	7.94	3.19	.13	−.37
Total no. of descriptives in SE[a]	19.00	14.55	11.06	6.12	.11	−.34
No. of time statements in SE	6.42	9.08	3.65	3.32	–	–

Note. Mean difference significant at: [a] $p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

Personal-Event Memory

Data from children's personal-event narratives were also evaluated using *t* tests and regression analyses that included group and age as predictors. The dependent variables of interest included the number of words, sentences, descriptives, and time statements children provided in their two event narratives (i.e., about the first day of school and a special event). Means and standard deviations for children with and without ADHD, as well as sr^2 and β, are presented in Table 3.

First Day of School Narrative

There were no significant differences between children with and without ADHD in the event narratives they provided about the first day of school. The number of words, sentences, descriptives, time statements, use of specific dialogue, and specificity of narrative were similar for the two groups.

Special-Event Narrative

Children with ADHD provided significantly more words and sentences than children without ADHD in their narratives about a special event. Children with ADHD also provided more descriptives than children without ADHD, a difference that reached a marginal level of significance. Regression analyses including group and age as predictors revealed that only group made a statistically significant contribution to any of these effects. For group, the sr^2 for words in the narrative was .184, $t(29) = -2.49$, $p = .020$ with $\beta = -.441$, the sr^2 for sentences in the narrative was .127, $t(29) = -1.97$, $p = .060$ with $\beta = -.366$, and the sr^2 for descriptives in the narrative was .109, $t(29) = -1.82$, $p = .081$ with $\beta = -.339$. There was no significant difference in the number of time statements, use of specific dialogue, or specificity of narrative for the two groups.

To summarize, the results were in the hypothesized direction. There were no significant between-group differences in the first day of school narrative reports. However, as Table 3 illustrates, independent of age, children with ADHD provided longer and more detailed special-event narratives than controls. The variance explained by the unique contribution of group ranged from 12 percent to 18 percent across outcome variables.

Story Memory

Data from verbal recall and picture recognition tasks based on the 10 novel stories was analyzed in much the same way as the other memory data, using *t* tests and regression analyses that included group and age as predictors.

Recall of Central and Peripheral Details

At the beginning of the recall task for each story, children were shown a picture of the main character, told his or her name, and asked, "Tell me everything you remember about him/her." There was a ceiling effect whereby children in both groups provided at least one piece of accurate central information about every story plot in response to this question (e.g., "Jimmy had a bike") and no errors occurred. After seeing the main character, children were shown a blank screen and were asked a total of 40 direct questions about central and peripheral details, which were scored as correct or incorrect. There was no significant difference in the number of central details (participants with ADHD $M = 13.75$, $SD = 2.59$; participants without ADHD $M = 13.58$, $SD = 2.47$, *ns*), peripheral details (participants with ADHD $M = 11.25$, $SD = 3.74$; participants without ADHD $M = 12$, $SD = 3.72$, *ns*), or total details (participants with ADHD $M = 25$, $SD = 5.76$; participants without ADHD $M = 25.58$, $SD = 5.28$, *ns*) that children in the two groups correctly recalled.

There was a positive and significant correlation between the number of correct answers children gave to questions related to central details and the number of correct answers they gave to questions related to peripheral details across the whole sample ($r(29) = .511$, $p = .005$). Among children with ADHD this pattern was highly significant ($r(12) = .642$, $p = .024$), while among children without ADHD the pattern was marginally significant ($r(17) = .427$, $p = .087$).

Recognition of Pictures

In the first part of the picture recognition task, children were shown two central pictures of objects from each of the stories that had originally been accompanied by peripheral pictures, for a total of 20 pictures. While viewing each central picture, children were asked, "Do you recognize this picture? What is it?" In response, children in both groups were highly accurate at identifying the context in which they had seen the objects, for example, correctly identifying "Jimmy's bike" (participants with ADHD $M = 19.83$ $SD = .39$; participants without ADHD $M = 19.71$, $SD = .59$ of 20 possible correct identifications, *ns*). In contrast, with few exceptions, children were unable to generate any of the peripheral pictures that had appeared around the central pictures (participants with

ADHD $M = .33$, $SD = .78$; participants without ADHD $M = .18$, $SD = .53$ of a possible 80 peripheral pictures originally shown, ns). In the second part of the picture recognition task, children were presented sequentially with 30 peripheral pictures that had been present and 30 pictures that had not been present in the stories and were asked to say "yes" or "no" to whether each had appeared in the stories. Children with and without ADHD were equally accurate in doing so, as indicated by percentage correct (participants with ADHD $M = .34$, $SD = .18$; participants without ADHD $M = .36$, $SD = .19$, ns). Children in the two groups were also equally likely to say "yes" to having seen a particular picture during the story, independent of whether that answer was correct (participants with ADHD $M = 13.67$, $SD = 9.08$; participants without ADHD $M = 16.41$, $SD = 8.16$, ns). However, there was a marginally significant difference between the groups in the percentage of time that they were in fact correct when they answered yes, with children with ADHD being slightly more accurate, $t(27) = 1.92$, $p = .065$ (participants with ADHD $M = .79$, $SD = .15$; participants without ADHD $M = .69$, $SD = .16$).

To summarize, children with and without ADHD were similar in their ability to recall both central and peripheral details from the story; both groups did equally well when answering direct questions. There was a strong positive correlation between the number of correct answers to central detail questions and peripheral detail questions, and this correlation appeared stronger among children with than children without ADHD. There was a ceiling effect among children with and without ADHD in the ability to identify central pictures from the stories, and there was a floor effect in the ability to generate the peripheral pictures that surrounded them. On the "yes/no" recognition task, both groups were equally accurate in discriminating between peripheral pictures that had been present and lures that had not.

DISCUSSION

The goal of this study was to examine parents' observations of the memory performance of children with and without ADHD and the actual memory performance of these children on laboratory working memory and long-term episodic tasks. The study was motivated by observations in the clinical literature that children with ADHD may suffer from memory failure in the classroom but perform well when remembering personally experienced past events (Levine, 2002). From the perspective of memory research, we surmised that this performance difference might reflect a relative weakness among children with ADHD in semantic and working memory, coupled with a relative strength in long-term episodic memory. Our study represents the first attempt to obtain direct empirical evidence for such a memory profile among children with ADHD.

Overall, the pattern of findings we obtained for both parent ratings and children's memory performance supported clinical insights and our associated predictions. In comparison with parents of children without ADHD, parents of children with ADHD rated their children as weaker on some key tasks reflecting semantic memory, and rated their children

as better on long-term event memory. Consistent with this, the actual performance of children with ADHD was weaker than the performance of children without ADHD on working memory tasks, but it was as strong or stronger on long-term episodic memory tasks. In the following discussion, we first consider parent ratings and then turn to working memory and long-term episodic memory tasks and their implications for educational practices.

Parent Ratings

Results of the 22-item parent questionnaire supported Levine's (2002) suggestion that clinicians and parents of children with ADHD see an inconsistent memory profile among these children. In comparison with parents of children without ADHD, parents of children with ADHD rated their children significantly lower on a number of semantic and school-related memory questions, including remembering spelling, math, and people's names. There was no difference between groups in parents' ratings of their children's ability to remember factual information in general or memory in other academic subjects (e.g., history, geography). Thus, parents' ratings may reflect observation of their children struggling in particular subjects in which competent performance during elementary school relies particularly heavily on semantic or working memory processes, rather than an overall perceived deficit.

Differences between the ratings of parents of children with and without ADHD emerged for several questions surrounding children's ability to tell jokes. Parents rated children with ADHD as much worse at telling jokes, more frequently unable to remember parts of a joke, and more frequently disposed to tell jokes in the wrong order. We were inspired to ask parents about their children's joke-telling ability after recognizing that the working memory deficits and problems with sequencing and temporal order reported among children with ADHD (Barkley, 1997) might affect this ability. When first encoding a joke, an individual must be able to hold in mind the plot while attending to and anticipating the punch line. Once the whole joke is heard the individual must be able to store the joke in the proper sequence and then retrieve/recall the joke in the proper sequential order. Deficits in behavioral inhibition allow for interference in this process and predict a temporally disorganized recall in which "the very syntax should be deficient" (Barkley, 1997, p. 77), consistent with parent ratings suggesting that children with ADHD may often forget parts of jokes or tell them in the wrong order. Along these lines, it is also not surprising that children with ADHD were rated as worse at remembering people's names.

Parents of children with ADHD rated their children higher than did parents of children without ADHD on recalling specific details of past experiences compared to the rest of the family. This finding buttresses anecdotal accounts suggesting that parents of children with ADHD are likely to identify them as having "the best memory in the family" for specific details of past experiences. This result, combined with evidence of memory deficiencies among children with ADHD, lends some insight into the struggles that have been anecdotally expressed by parents (Levine, 2002). How can a parent

make sense out of this paradox: their child appears to recall specific details from the past, but cannot remember his spelling words?

Working Memory

In this study, participants with ADHD scored significantly lower than participants without ADHD on the digit span task and the Simon game task that were measures of working memory. These results replicated the findings of previous studies comparing participants with and without ADHD on the same tasks (e.g., Barkley, 1997, 1998a; Kerns, McInerney, & Wilde, 2001; Murphy et al., 2001). The results indicated that participants with ADHD, who were selected from a private school and screened for inclusion based on diagnoses reported to us by parents, were similar to populations selected in other studies. The results of the working memory tasks are also consistent with clinical and parent observations that children with ADHD often have difficulty memorizing factual information such as spelling words and math facts. Working memory plays a key role in these and other academic activities children regularly engage in during the elementary school years.

Personal-Event Memory

In contrast to their relatively poorer performance on working memory tasks, children with ADHD provided lengthier and more descriptive special-event narratives. These results lend some validation to parent observations, which suggests that personal-event memory may be a strength for children with ADHD in daily life. The results provide the first empirical support for the notion that children with ADHD may exhibit more elaborate long-term episodic memory than children without ADHD when recalling personally experienced past events.

The finding that children with ADHD provided lengthier narratives is somewhat consistent with past indications that, in general, children with ADHD talk more to others and themselves as a result of poor behavioral inhibition (Barkley, 1997, 1998b). In fact, one of the criteria for diagnosing hyperactivity is excessive talking (American Psychiatric Association, 1994). However, there are several pieces of evidence that indicate that excessive talking is not responsible for the longer and more descriptive special-event narratives that children with ADHD provided in our study. First, if the use of more words and sentences were simply a function of excessive talking, we would expect to see differences between those children who had been diagnosed with ADHD primarily hyperactive/impulsive and ADHD primarily inattentive subtypes. Although the small sample size in this study did not allow us to compare these groups statistically, inspection of the means revealed no differences between diagnostic subtypes on these variables. Perhaps more important, the group differences we obtained did not extend to the first day of school narrative, which would be expected if children with ADHD were simply talking more in an indiscriminate way across tasks.

Why wasn't there a difference between groups in children's accounts of the first day of school, as opposed to a special event in their lives? If in retrieving memories about the first day of the school year children focused primarily on script-like information about what usually happens on such days, their memories would be less likely to be enhanced by specific, idiosyncratic details. In any event, similar scores between the two groups for length and number of details associated with memories of the first day of school indicated that memory among children with ADHD for this event was intact.

A null effect that is worth noting is that there were no group differences in the use of time statements. According to Barkley (1997), conversations with children with ADHD "should reflect fewer references to time, the past, and especially the future" (p.78). Although researchers have found deficits in sequencing and temporal organization, it is unclear whether the recall of personal-event memory is likely to be as "temporally disorganized" among children with ADHD (Barkley, 1997, p. 77) as other aspects of memory. Salient personal events may be more conducive to temporal organization (McKoon, Ratcliff, & Dell, 1986) because recalling what happened first in an event leads to what happened second and may further strengthen the account. It is also possible that the relatively brief narratives children provided in our study did not allow for enough references to time to reveal group differences that may have been apparent in more extensive and numerous narratives.

Our results highlight the struggles that parents and educators experience when dealing with children with ADHD, who appear to have the potential to recall specific, minute details of events and yet struggle in school to recall semantic information. This pattern of enhanced episodic memory amid poor semantic memory appears consistent with the poor interference control children with ADHD experience, which is associated with dysfunctions of the prefrontal cortex more specifically the right prefrontal region, which has been found to be smaller in children with ADHD (Barkley, 1997). On narrative tasks like the ones in our study, recalling details that are peripheral to the meaning of an event will typically enhance a narrative, making it longer, more descriptive, and arguably more interesting. On most semantic and working memory tasks, including those that children face regularly in school, such details are more likely to detract from performance.

Story Memory

Story memory represented an alternative long-term episodic memory task. The importance of the story memory results are contained in the fact that on all story memory measures, children with ADHD did as well as children without ADHD. Children with ADHD recalled as many central details, peripheral details, and total details in response to open-ended and direct questions about the stories as did their peers without ADHD. Identification of the context in which central pictures had originally been shown and recognition of pictures that had been present in the stories was also equivalent across groups. In view of the results for the working memory tasks in which children with ADHD showed poorer performance

than children without ADHD, this comparable performance between groups on story memory and picture recognition tasks is consistent with the notion that long-term episodic memory is a relative strength for these children.

The positive correlation—across the sample and particularly among children with ADHD—between the number of correct answers to central questions and the number of correct answers to peripheral questions about the story is worth noting. These data may simply reflect the fact that some children in the sample had better memory for both kinds of questions. Nonetheless, these data underscore the notion that, under some conditions, recalling peripheral information about a story or event may increase the likelihood that an individual will also recall central information. For children with ADHD, who are likely to have attention diverted in the direction of peripheral details at encoding, such details may serve to activate related central information that makes it into a story or event representation in memory.

Unfortunately, in many classroom situations, the peripheral information children with ADHD take in may be largely disconnected from the central information they are required to remember for optimal class and test performance. In such cases, remembering peripheral information is likely to be of limited utility, because it does not serve as a pathway back to central information. When the curriculum focuses narrowly on memorizing isolated facts, for example, peripheral information that is not clearly linked conceptually to those facts in the child's knowledge base will not assist recall. Moreover, if a child is unable to inhibit attention to extraneous stimuli, especially during a goal-oriented task such as learning spelling words or historical facts, then the child will not be able to recall that central information because such interference will prevent its proper encoding and storage.

The combination of these results lends some insight into a way to help children with ADHD improve their performance in the educational system. As Nuthall and Alton-Lee (1995) and Pillemer (1998, 2001) have suggested, the use of specific one-moment-in-time episodes in the classroom may allow for the integration of related peripheral information into the semantic-oriented learning tasks. This can be done through the use of hands-on experiences, jokes, anecdotes, and mnemonics when teaching in different disciplines. Even field trips can be beneficial in creating these episodes. Such a hands-on approach may benefit children with ADHD especially. Based on the combined results in this study for parent ratings, personal-event memory, and story recall, it would not be surprising if children with ADHD recalled more details of such "educational episodes" (Pillemer, 1998, p. 8). In theory, children with ADHD could use such information to get back to information central to the curriculum, and they might be inclined to do so to compensate for less effective working and semantic memory. After all, as Martin (1993) noted, people commonly recall specific events that occur in educational contexts. Furthermore, as Nuthall and Alton-Lee's (1995) interviews with elementary school children illustrated, personal-event memory is probably recruited by children regularly in the service of getting back to factual information, as on an exam. The challenge for educators may be in providing experiences for children with ADHD in which peripheral or contextual information is effectively connected to the central information in a lesson and in facilitating children's ability to make the connection between the two kinds of information.

Future work is needed to confirm the pattern of differences in the memory profiles of children with and without ADHD reported in this study, establish the boundary conditions under which these differences occur, and fully explain them. Nonetheless, it seems valuable for parents, teachers, and clinicians who support children with ADHD to recognize that the diagnosis may carry with it not only memory liabilities, but also memory strengths. Perhaps in recognizing this, we may begin to capitalize on the memory strengths of children with ADHD, helping them reach their potential in an educational system where failure and frustration has too often been the norm.

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APPENDIX A

Example of the Stories and Questions in the Story Memory Task

(*Central and peripheral details are denoted below by either a C or P. Central pictures are described below and occasions when they appear with peripheral pictures are noted.*)

Jimmy is a 13-year-old boy (picture of a boy). He loves to ride his shining (P) black (P) bike (C) (picture of bike with four peripheral pictures). The other day, Jimmy went out bike riding and met up with three of his friends (C), whom he has known for four years (P). Together they rode to the park (P) (picture of a park). On the way they began racing their bikes (C). Jimmy was winning (P) until he fell off his bike(C) (picture of boy falling off bike). Luckily he was wearing his helmet and did not get hurt (C) (picture of helmet and four peripheral pictures). Unfortunately, the back wheel fell off his bike (C) (picture of wheel with four peripheral pictures). He had to carry his bike (P) all the way home. When he got home his parents were happy he did not get hurt (C). It costs $10 (P) to replace the wheel on the bike. He road the bike the day it was fixed.

*Story contains 10 sentences, 6 pictures (3 presented with peripheral pictures and three without), 7 central, and 7 peripheral narrative details

Identification question: This is Jimmy (show picture). Tell me everything you remember about Jimmy.

Direct questions- What happened when Jimmy was racing on his bike? (Central)

What happened to Jimmy's bike when he fell off? (Central)

What color was Jimmy's bike? (Peripheral)

How much did it cost to fix the bike? (Peripheral)

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