2004

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Original Publication Citation

Westby, C., & Watson, S. (2004). Perspectives on attention deficit hyperactivity disorder: Executive functions, working memory, and language disabilities. *Seminars in Speech and Language, 25*(3), 241-254. doi: 10.1055/s-2004-833672

Perspectives on Attention Deficit Hyperactivity Disorder: Executive Functions, Working Memory, and Language Disabilities

Carol Westby, Ph.D.,[1] and Silvana Watson, Ph.D.[2]

ABSTRACT

The conceptualization of the nature of attention deficit hyperactivity disorder (ADHD) has changed in the last decade. ADHD is now viewed as a neurologically based condition with primary deficits in executive functions and working memory (WM). Students with ADHD have deficits in discourse organization, inferring, and monitoring that are related to their executive function and WM deficits. A large number of students with ADHD also have comorbid reading and language disabilities that exist in addition to the deficits directly associated with the ADHD. Comprehensive evaluation of students with ADHD is essential to address their specific learning needs.

KEYWORDS: ADHD, working memory, executive function, language disabilities

Learning Outcomes: As a result of this activity, the reader will be able to (1) describe assessment devices commonly used to appraise executive function in children with ADHD and their typical performance profiles; (2) explain the impact of ADHD on discourse function, language, and reading; and (3) develop an appropriate assessment plan to identify and treat concomitant problems in executive function, WM, and language use in students with ADHD.

ADHD is now one of the most commonly diagnosed conditions of childhood. In the United States approximately 3 to 5% of the population has ADHD.[1] Some critics have questioned whether ADHD is a legitimate diagnosis. They suggest that children who are labeled ADHD are actually normal children whose parents and teachers are intolerant of behavioral variations. If ADHD did not represent a true disorder, however, there should be

Attention Deficit Hyperactivity Disorder: An Update on Research and Clinical Implications; Editors in Chief, Nancy Helm-Estabrooks, Sc.D., and Nan Bernstein Ratner, Ed.D.; Guest Editor, Jack S. Damico, Ph.D. *Seminars in Speech and Language*, volume 25, number 3, 2004. Address for correspondence and reprint requests: Carol Westby, Ph.D., 1808 Princeton NE, Albuquerque, NM 87106. E-mail: mocha@unm.edu. [1]University of New Mexico, Albuquerque, New Mexico; [2]Old Dominion University, Norfolk, Virginia. 0734-0478,p;2004,25,03,241,254,ftx,en;ssl00203x.

no differences in any cognitive, behavioral, and social outcomes of normal children and children labeled as having ADHD, and studies of etiology should show no differences between children with and without ADHD. In actuality, numerous studies have shown poorer long-term outcomes for individuals with ADHD and neurological differences between students with and without ADHD.[1] The conceptualization of the nature of ADHD has changed in the last decade. This article will discuss (1) current conceptualizations of ADHD as a deficit in executive functioning and WM, (2) comorbid and associated disorders seen in students with ADHD, and (3) implications of these characteristics for the assessment of students with ADHD.

FRAMEWORK FOR UNDERSTANDING ADHD

Since the publication of the third edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-III*),[2] ADHD has been reconceptualized as comprising three core clusters of behavioral symptoms: poor sustained attention, impulsiveness, and hyperactivity. In *DSM-IV*,[3] the diagnostic criteria were separated into two specific domains (inattention and hyperactivity/impulsivity). The two domains yield three subtypes of ADHD: predominantly hyperactive-impulsive (HI), predominantly inattentive (IA), and a combined type. Research has shown that persons with HI and combined types of ADHD exhibit deficits in executive functioning and WM.

Executive Functioning

Converging evidence from clinical, neurobiological, and neuropsychological studies suggests that the surface behavioral manifestations in ADHD reflect an underlying problem in executive function.[4–6] Executive functioning refers to self-regulatory behaviors necessary to select and sustain actions and guide the behavior within the context of goals and rules. Executive functioning involves developing and implementing an approach to performing a task that is not habitually performed. One must initiate, plan, shift attention or thought, organize, inhibit inappropriate thought or behavior, and sustain the necessary sequence of behavior. Prior conceptualizations of ADHD as a primary problem of attention or impulsivity are losing their explanatory and prescriptive power and are being replaced with constructs, including poor self-regulation, particularly behavioral inhibition and WM deficits that underlie executive functioning.[7–10] In such accounts, rather than being distracted, the child fails to follow through on rules or instructions when presented with competing, highly rewarding activities. Barkley[11] has hypothesized that difficulty with adherence to rules and instructions is a primary deficit of children with ADHD. Based on this conceptualization, Barkley[11] provided the following definition of ADHD:

> ADHD consists of developmental deficiencies in the regulation and maintenance of behavior by rules and consequences. These deficiencies give rise to problems with inhibiting, initiating, or sustaining responses to tasks or stimuli and adhering to rules or instructions, particularly in situations where consequences for such behavior are delayed, weak, or nonexistent (p. 71).

This definition of ADHD has significant implications for how the social and academic deficits of children with ADHD are understood and treated.

Barkley's[7] proposed model of ADHD was designed to account for the multiple problems exhibited by persons with the HI and combined HI/IA types of ADHD. (The model does not apply to the subtype of IA classified as the predominantly IA type in the *DSM-IV*). Barkley hypothesized that individuals with ADHD have difficulty in inhibiting behavior. They have difficulty stopping a dominant response or the urge to act, interrupting an ongoing pattern of behavior that is producing signs of being ineffective, and protecting periods of concentration and self-regulation from being disrupted by both outside and inside sources of interference.

Behavioral inhibition provides the critical support for executive functioning. Barkley[7] proposed four components of executive

functioning: (1) nonverbal WM; (2) verbal WM; (3) regulation of affect, arousal, and motivation; and (4) the ability to recombine behavioral sequences in novel, hierarchically organized goal-directed behaviors. These four executive functions permit motor control and fluency, affording effective self-regulation and adaptive functioning that direct and control the motor system so as to achieve a particular goal.

Several tasks have typically been used to evaluate executive functioning. Among them are

- *The Stroop Color and Word Test*[12,13]: This well-known and highly researched assessment tool uses cards with the names of colors spelled out (e.g., "blue") but printed in the ink of another color (e.g., red). The student is instructed to say the name of the ink rather than the word. This task requires the student to inhibit the normal tendency when reading, which is to attend to the word and ignoring the ink color. An adapted version of this task for children,[14] the *Day-Night Stroop*, includes two kinds of cards. One face of half of the cards is white with a bright sun, to which the child is instructed to say, "night." The other card has a back face with a moon and stars, to which the child is told to say, "day."
- *Wisconsin Card Sorting Test*[15]: This test, which can be used with persons from 6.5 years through adulthood, allows clinicians to assess strategic planning, organized searching, and using feedback to shift cognitive sets and direct behavior. Four cards varying in color, shape, and number are placed in front of the students. The student is asked to match cards from two decks with one of the four "key" cards, and the clinician tells the student whether the cards were sorted correctly. After 10 consecutive correct matches, the sorting principle is changed without the student's knowledge, and the clinician gives negative feedback to the student on his or her previous successful strategy. The child's score reflects the ability to inhibit previous response patterns and an ability to shift to a new response set. Performance reflects ineffective hypothesis testing, perseveration, and difficulty in maintaining a mental set in the presence of completing stimuli.
- *Trail Making Tests, A* and *B*[16]: This device measures psychomotor speed, cognitive flexibility, divided attention, sequencing, and visual tracking. Trail A consists of numbers randomly placed on a page. The participant draws a line from one number to the next in sequential order. Scoring is based on accuracy and time. Accurate performance on this test relies on attention and visuomotor speed and tracking, intact visual directional scanning, and the handling of serial information. Trail B has both number and letters randomly scattered on a page. The participant alternates drawing a line between number and letters in sequential order (1, A, 2, B, 3, C, and so on). Trail B particularly taps executive functioning (e.g., planning and cognitive flexibility). Trail Color is a version adapted for use with children and is designed to minimize any effects of reading ability.[17]
- Word fluency or letter word fluency: Verbal fluency tests, known by several terms, for example, the FAS test and controlled oral word association, include tests of letter and semantic fluency. Several child cognitive and language assessments ask children to name in 1 minute as many items as they can that belong in a category (e.g., animal, things to eat, things to wear). Older children and adults are asked to generate as many words as possible that begin with particular letters.[18] Verbal fluency tests have two components: (1) a linguistic component and (2) an ideation component associated with frontal lobe function. Performance is assumed to reflect automatic lexical access; efficient lexical production; WM; and the ability to self-monitor, initiate, and shift. Performance, however, is not independent of intelligence, vocabulary skills, and attention.

Although performance on these tasks is associated with advancing age in children and adolescents, children and adults with ADHD generally exhibit poorer performance on the instruments than do persons without ADHD. Numerous studies in neuropsychology have indicated that the tasks are mediated by the prefrontal areas of the brain, which are

responsible for executive functioning involving the ability to maintain a set in problem solving and carrying out a sequential plan, making mental representations of the task, and planning and monitoring performance.[6,19]

Working Memory

Executive functioning depends on WM, which involves short-term storage as well as processing, manipulation, and transformation of stored information.[20] Two major frameworks have been proposed to explain the functioning of WM, that proposed by Baddeley[21] and the models proposed by various neo-Piagetians.[22,23] The work of Baddeley and the neo-Piagetians represents two different lines of research, but the two models can be seen as complementary.[24,25] Baddeley's model has three components: a phonological loop, a visual sketch pad, and a central executor.[21] The phonological loop and visual sketchpad represent verbal and visual short-term memory (STM). These two components and the central executor combined represent WM. STM involves storage of information for a limited period of time and reproduction of that information. WM serves as a workbench. It brings together the present contents of STM, retrieved or activated long-term memory (LTM), and future goals and plans.[26] Text comprehension requires efficient WM because the listener or reader must process the language online while retrieving information from LTM and building a mental model for the text that is a representation of the situation or world (real or imaginary) described in the text. Mental models are necessary for inferring that is essential for comprehension.[27]

The neo-Piagetian models of WM also involve an executive system, but their emphasis has been on what is termed the M-capacity, defined as the maximum number of discrete chunks of information or independent schemes that can be activated and manipulated. M-capacity increases by 1 informational unit every 2nd year, from 1 at age 3 to the adult capacity of 7 at age 15.[28] The neo-Piagetian approach is particularly useful in explaining the complexity of tasks—how many pieces of information a student must simultaneously hold in mind and manipulate. The more pieces that must be held and manipulated, the more complex the task. The less automatic any component of a task is for a student, the more space will need to be devoted to it in WM. As children mature, they become able to manipulate increasing numbers of pieces of information and, consequently, can comprehend more complex texts.[29]

Both the Baddeley[21] and neo-Piagetian models[22,23] include nonverbal and verbal WM components. Nonverbal or spatial WM is the capacity to hold events and information in mind so as to imitate complex sequences of behaviors. The use of nonverbal WM to activate past sensory events allows for hindsight and forethought. The retention of a sequence of events in WM also provides the basis for the human sense of time. Nonverbal or spatial WM is also involved in the development of mental models that underlie discourse comprehension.

Verbal WM is internalized language that is used to talk with oneself to provide reflection, description, instruction, and questioning, which in turn facilitate problem solving, the development of rules, and moral reasoning. ADHD disrupts the development of internalization of speech because it disrupts the inhibition needed to support internalized speech. Without internalized speech, one will fail to develop appreciation of rule-governed behavior and, without this, one lacks self-regulation. Deficits in verbal WM will contribute to difficulties in regulating affect, motivation, and arousal. Both verbal and nonverbal memory are essential for problem solving that involves recombinations of behavioral sequences in hierarchical goal-directed patterns.

Current theories of discourse processing propose that WM is used to construct, maintain, and update detailed and coherent mental representations of both explicit (facts) and implied (inferential) information during listening and reading. Greater understanding and ability to recall facts and make inferences are associated with more elaborate mental representations.[30] Because WM involves both storage and processing, assessment of WM involves tasks that require simultaneous storage and processing. Daneman and Carpenter[31] developed

what has become a classic measure of WM. They had participants read sets of sentences and concurrently remember the last word from each sentence in the set. In addition to the Daneman and Carpenter task, the following assessments have typically been considered tests of WM:

- *Competing Language Processing Task*[32]: This is a variant of the Daneman and Carpenter task for children. The child reads simple sentences (e.g., "Trees have leaves," "Babies drive trucks," "Dishes whistle"). Groups of sentences are presented in increasing set sizes, from two to six sentences. The student is to first respond to the truth value of each statement (responding "true" or "false") and then to remember the last word of each sentence.
- Digit Span Backwards: The task of reciting numbers backwards appears on several cognitive and language assessments.
- Working Memory Span[33]: Students are orally presented with two, three, or four simple sentences one after another. Half of the sentences make sense (e.g., *The fireman ate the pie*) and half do not (e.g., *The man danced the food*). The student must identify which ones are absurd and also name the objects (e.g., banana) or the persons involved (e.g., fireman).
- Letter-Number Sequencing: This task appears on the *Children's Memory Scales*[34] and the *Wechsler Children Intelligence Scale, Fourth Edition*.[35] The assessment consists of a series of orally presented letters and numbers that are presented in a randomized order. On each trial, the examiner reads aloud a series of alternating numbers and letters (e.g., 9K3E2). The student must reorder each sequence mentally and say the numbers first in ascending order and then the letters in alphabetical order.

Studies have revealed that students with language disabilities[36–38] and students with ADHD exhibit deficits in WM[39,40] on such devices. These WM deficits influence children's ability to learn new words, comprehend syntactically complex sentences, and organize extended discourse.

Rapid Automatic Naming

Rapid automatic naming (RAN) is typically measured by timing persons as they identify digits, numbers, familiar pictures, or colors and shapes (e.g., red triangle, blue circle). The letter and word fluency tasks described earlier to evaluate executive functioning differ from RAN. In RAN tasks, children see a series of targets (e.g., letters, objects) that they must quickly name. RAN tasks, unlike the letter and word fluency tasks, requires no spontaneous generation of words. RAN is used as a diagnostic indicator of reading difficulties, serving as a marker of visuoverbal connection and processing speed. RAN is not part of WM, but efficient RAN frees space in WM so that WM capacity is increased. Persons with slow RAN will have less space available in WM to manipulate pieces of information. Interest in RAN has increased in recent years as a result of reading studies identifying a double deficit in some forms of dyslexia, specifically, those students whose reading difficulties are accompanied by deficits in phonological processing and phonemic awareness as well as rapid automatic naming.[41,42] RAN appears to be more closely related to semantic aspects of language ability than to phonological aspects. Students who exhibit difficulty in both phonological awareness and RAN exhibit more severe reading problems than students who have only a single deficit in either phonological awareness or RAN.

ASSOCIATED AND COMORBID DISORDERS

ADHD rarely occurs in isolation. Between 50 and 80% of children with ADHD also meet diagnostic criteria for other disorders.[43] Persons with ADHD will exhibit associated disorders that are directly related to the executive dysfunction and WM deficits of ADHD itself. Many persons will also exhibit comorbid disorders that are not part of the ADHD but that exist in addition to it. Figure 1 shows the relationships between ADHD only and associated and comorbid disorders as well as the types of language and reading disorders associated with ADHD only and ADHD and comorbid disorders.

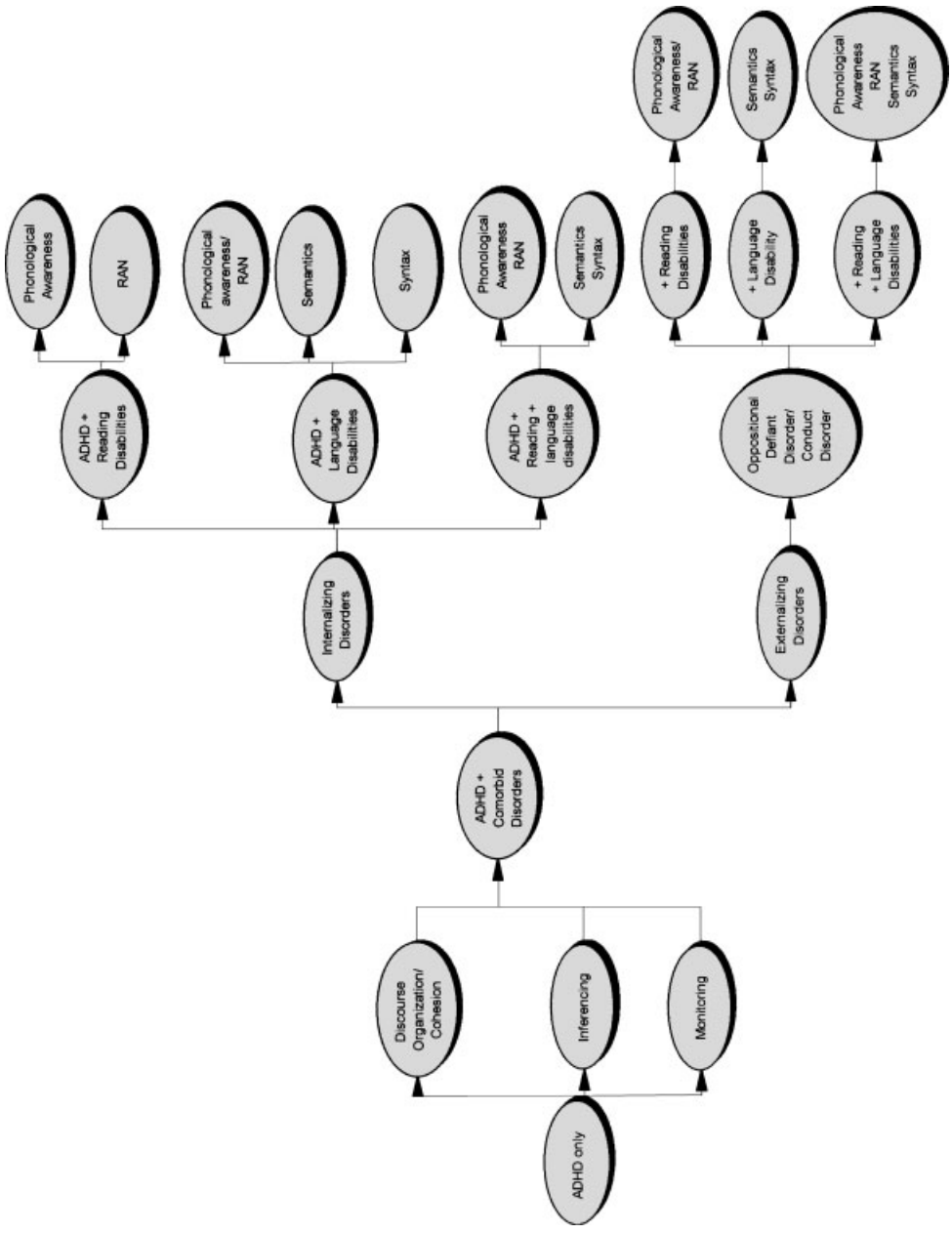

Figure 1 ADHD and related disabilities.

When discussing the relationships among ADHD, associated, and comorbid conditions, one must identify the nature of the ADHD being described. Current evidence suggests that different subtypes of ADHD have differing associated and comorbid conditions. The two symptom clusters as described in *DSM-IV* (inattention and hyperactivity-impulsivity) are thought to be distinct in terms of their etiology, clinical course, related and comorbid conditions, response to treatment, and outcomes. In general, the IA type is thought to be associated more with processing disorders and internalizing disorders such as reading, language-learning disabilities, and anxiety. The HI type is thought to be associated more with executive function disorders and externalizing disorders, such as oppositional defiant disorder and conduct disorders.[44,45] The combined HI and IA group demonstrates the most severe problems in all areas. Despite the increasing evidence that the HI and IA types of hyperactivity are distinct groups with differing etiologies and responses to interventions, few investigators have differentiated these groups in their studies of students with ADHD.

ADHD Only and Associated Disorders

Children with ADHD only have age-appropriate scores on traditional tests of intelligence and language. They are also likely to have age-appropriate scores on reading tests that focus on decoding or reading of sentences or very short passages. Such students, however, are likely to have deficits with discourse skills necessary for comprehension and production of narrative and expository texts, particularly as the texts become more complex. These higher-level language deficits are considered to be associated disorders because they are viewed as part of the primary ADHD. The associated disorders are directly related to the impairments in executive function and WM.

Deficits in self-regulation are a hallmark of executive function deficits. As a result of their executive function deficits, children with ADHD seem to have more trouble "doing what they know" than "knowing what to do." They are less able than same-aged peers to resist forbidden temptations. Such rule following is particularly difficult for children with ADHD when the rules compete with rewards available for committing rule violations such as playing computer games rather than doing homework.[46] They are also less likely to use organization rules and strategies in their performance of memory tasks, and they are less likely to transfer the rules they have acquired on a prior task to a new task.[47] These deficits in rule-governed behavior affect children's social skills. Children with ADHD have also been shown to have less knowledge about social skills and appropriate behavior with others.[48] They seem to lack self-talk critical to the control and organization of interpersonal behavior. As a consequence, they do not read essential verbal, nonverbal, and situational cues or make decisions based on that evidence in accordance with social expectations.[49]

Language Disabilities in ADHD Only

These deficits in rule-governed behavior may be related to children's delayed internalization of language. Studies of children with ADHD have consistently found that the children are less mature in their self-speech.[50,51] Lack of private, self-directed speech also affects their ability to modulate emotional reactions. Because expression of negative emotions is more socially unacceptable, students' difficulties in managing these emotions is problematic in relationships with teachers, peers, and parents.

Although ADHD only is not accompanied by significant general language delays in use of syntax or semantics, evidence shows a strong association between ADHD and communication disorders, particularly expressive, pragmatic, and discourse organization deficits.[8,52–54] These deficits are evident in both interpersonal and intrapersonal domains (i.e., in language used for social communication and in that used for self-regulation). The *DSM-IV* criteria for ADHD reveal a set of communication problems characteristic of pragmatic dysfunction (e.g., difficulty awaiting turns, talking excessively, interrupting others, not listening to what is being said, and blurting out answers to questions before they are completed). Compared with children who are developing typically, children with ADHD have

difficulties characterized by excessive verbal output during spontaneous conversations and task transitions and in play settings. In contrast, they tend to produce less speech in response to confrontational questioning than do children without ADHD.[54,55] They are also less competitive in verbal problem-solving tasks and less capable of communicating task-essential information to peers in cooperative tasks.[56] They produce less information and less organized information in tasks that require planning and verbal organization, such as story narratives,[53,57,58] or in describing the strategies they use during task performance.[59] They exhibit difficulties in introducing, maintaining, and changing topics appropriately; in negotiating smooth interchanges or taking turns during conversation; and in adjusting language to the listener in specific contexts.[60]

Purvis and Tannock[61] investigated the relationship of language abilities of ADHD children with and without reading disabilities. Students were required to retell a lengthy narrative and to complete tests assessing semantic knowledge. Children with ADHD (ADHD only and ADHD plus reading disabilities) exhibited difficulties in organizing and monitoring their story retelling. Children with reading disabilities (reading disabilities only and ADHD plus reading disabilities) also demonstrated deficits in receptive and expressive language abilities. Purvis and Tannock concluded that the deficiencies of children with ADHD were consistent with higher-order executive function deficits, whereas the deficits of children with reading disabilities were consistent with deficits in the basic semantics of language processing.

McInnes et al[8] asked typically developing students, students with ADHD only, and students with ADHD plus language impairment to listen to expository passages and answer factual and inferential questions. For example, the students read a passage about mummies. They then responded to factual questions that were explicitly answered by the text (e.g., "Who turned the king's body into a mummy?" or "What was used to dry the king's body?"). They next answered inferential questions, such as "What did the mummy smell like when it was put in the tomb?" or "What did the king think he would need in his afterlife?" They were also asked to respond to true-false questions requiring inference and then to explain the basis for their answers. The authors found that the students with ADHD plus language impairment correctly answered fewer explicit and inferential questions than did the typically developing and ADHD only students. The ADHD only students correctly answered as many explicit questions as the typically developing students did, but they answered fewer inferential questions. Answering explicit questions requires STM, whereas answering inferential questions requires WM, which is apparently deficient in some children with ADHD.

Reading Disabilities in ADHD Only

The inferring deficits that students with ADHD only exhibit in listening tasks are also exhibited in their reading. Students with ADHD only also exhibit deficits in monitoring what they are reading.[8,59] They fail to notice inconsistencies in texts or to monitor ongoing comprehension of what they are reading. This failure to monitor is due to the deficits they exhibit in executive functioning and affects their ability to inhibit inappropriate behaviors, to plan, and to develop and maintain mental representation of tasks and goals.[62] Students with good comprehension must understand the goal or purpose for their reading and must be able to evaluate how well they are achieving that goal. Students with executive function deficits may be distracted by detail when reading and thus fail to understand the main ideas of the text.[53,63,64] When students with ADHD do recognize their failure to comprehend, they may not possess, or use, appropriate strategies to repair their comprehension failure. However, reading difficulties in students with ADHD may be misinterpreted as stemming from attention or motivational issues. As a consequence, many students do not receive the appropriate interventions.

ADHD WITH COMORBID DISORDERS

In addition to the discourse organization, inferring, and monitoring deficits associated

with the executive function and WM deficits of ADHD, many students with ADHD are likely to have additional comorbid disabilities that are not a direct result of executive functioning and WM deficits.

ADHD and Language Impairment

Research in the United States and Canada has shown that there is a high incidence of speech and language impairment (SLI) in the population of children concurrently diagnosed with ADHD.[52,65–67] These studies, however, generally have not differentiated between the two symptom types of ADHD. Love and Thompson[67] reported that three fourths of children with a diagnosis of language disorder being seen at a child and family clinic in Toronto were also diagnosed as ADHD; two thirds of children diagnosed as ADHD also had a language disorder. These students exhibit delays and disorders in phonological, semantic, syntactic, and pragmatic development. Estimates of the overlap between ADHD and SLI vary from a low of 8% to a high of 90%, depending on the precise definitions of SLI, the nature of the SLI, and the methods used to diagnose ADHD.[53] Studies have found that, in general, children with ADHD are somewhat more delayed in the onset of talking in early childhood than normal children (6 to 35% versus 2 to 25% of normal children).[68,69]

ADHD and Reading Impairment

Reading impairments in children with ADHD having comorbid reading disabilities are typically characterized by deficits in phonological awareness or RAN, or both. Some children with comorbid reading disabilities also exhibit comorbid syntactic and semantic deficits related to broader-based language disorders that affect their reading comprehension.[8,70]

IMPLICATIONS FOR ASSESSMENT

Because of the discourse organization, inferring, and monitoring difficulties that students with ADHD are likely to exhibit as a result of executive functioning and WM deficits, and because of the high comorbidity of language, reading, and learning problems in students with ADHD, speech-language pathologists (SLPs) should be involved in providing assessments with these students. By evaluating aspects of WM and executive function in addition to more traditional measures of language, SLPs can be instrumental in identifying the specific learning needs of children with ADHD. Despite controversy over the use of medication in treating ADHD, drugs have been shown to be the most effective intervention in modifying the problematic symptoms of hyperactivity/impulsivity in students with ADHD. Medication facilitates the ability to inhibit and hence improves executive function, but there is no reason to assume that medication will automatically enable the executive processes that must be intact for higher-order language and literacy demands or directly influence any of the comorbid disorders associated with ADHD. Adequate assessment and intervention of students with ADHD must consider the variety and nature of the comorbid disorders they exhibit and plan specific interventions to address them. Social behavioral, language, and reading problems related to executive function deficits that are associated with the HI and combined subtypes of ADHD are likely to be missed in traditional assessments that focus on phonology, syntax, semantics, and decoding. Language assessment and intervention for students with ADHD must be broadened to incorporate tasks that involve organization of extended texts, inferring, and planning and monitoring.

Assessing Comorbid Disorders

The clinician must determine if a student with ADHD exhibits ADHD only or ADHD plus reading disabilities, ADHD plus language impairment, or ADHD plus language and reading impairment. If a student is experiencing reading difficulties in the classroom, the SLP should assess the student's phonological awareness skills and RAN. Several commercial assessments are available to do this. The *Comprehensive Test of Phonological Processing*,[71] normed for ages 5 to 24, assesses both phonological awareness skills and RAN. The *Phonological Awareness Test*,[72] for children age 5 to 10,

assesses phonological awareness skills and knowledge of phoneme/grapheme relationships. The *Phonological Awareness & Reading Profile*[73] yields a profile for phonological awareness, decoding, spelling, and RAN for students age 8 through 14 years. The *Clinical Evaluation of Language Functions-4* (CELF-4)[74] includes a subtest for RAN and a series of activities to evaluate phonological awareness skills. Students with pure reading disabilities have deficits in phonological awareness or RAN, or both, but they have age-appropriate syntactic and semantic skills. Many but not all children with reading problems, however, also have broader-based language deficits affecting their semantic (vocabulary) and syntactic abilities. If students have semantic or syntactic deficits, their reading comprehension ability will be affected. Clinicians should evaluate students' range of language abilities. Traditional language tests can be used to assess students' syntactic and semantic skills as, for example, the *Clinical Evaluation of Language Fundamentals-4*[73] or the *Comprehensive Assessment of Spoken Language*[75] can be used to assess basic language skills. If children have deficits in basic semantic and syntactic skills, they will likely have difficulty with higher-level discourse organization skills and inferring required for comprehension and production of narrative and expository texts. Students can, however, have age-appropriate semantic and syntactic skills, yet have deficits in higher-level discourse. Because language abilities and WM efficiency have a reciprocal relationship, Montgomery[76] suggested that it is important to evaluate both students' language skills and WM to differentiate linguistic from WM deficits. Particularly on more complex language tasks, a students' poor performance may be primarily due to WM deficits rather than linguistic deficits. The WM assessments described earlier in this article can be used for this purpose.

Assessing Associated Disorders

All students with ADHD should be evaluated for associated disorders characterized by deficits in inferring, planning, and discourse organization. Students with ADHD plus comorbid disorders will also exhibit the associated disorders of students with ADHD only. Because the associated disorders in inferring, planning, and discourse organization result from inefficient executive functioning and WM, the assessment tasks must involve simultaneous processing and manipulation of information.

The inferring required to comprehend oral and written texts can be assessed by using informal reading inventories such as the *Qualitative Reading Inventory-3*.[77] This assessment provides narrative and expository passages from preprimer to high school levels. Multiple passages at each level allow for students to both listen to and read texts. Explicit and inferential questions are asked about each passage. Because expository texts generally have a less familiar structure and content than narrative texts have, they place greater demands on WM. Consequently, students may perform adequately on narrative passages but not on expository passages.

Planning, which depends on executive functioning, is increasingly essential for social and academic demands as students progress through school. Students must be aware of planning and must be able to plan if they are to comprehend and produce narrative and expository texts. Plots in stories are driven by the goals and plans of characters. If students do not plan themselves, they are unlikely to recognize the planning of characters in stories, and, as a consequence, they do not fully understand the plot and theme of stories. Consequently, it is useful to assess students' planning strategies. Children's meta-awareness of planning can be assessed by asking questions: Imagine someone who does not know what planning is. Try to explain to him or her what it means. What things are planned? When will you carry out the things that you plan? Who plans? How often is planning done? What is the purpose of planning (what is it good for)? What are the results of planning? How is planning done? What does one feel when one plans? Is planning difficult or not? What are the difficulties in planning? Is planning important or not? (See Kreitler and Kreiter,[78] p. 213.)

Students can also be given tasks that require that they produce a plan; for example, they can be told the beginning and end of a story and be asked to fill in the middle, which will require that they produce a plan to deal

with the problem described in the story. An example might be the following:

Al (Joyce) moved into the neighborhood. He (she) didn't know anyone and felt very lonely. The story ends with Al (Joyce) having many good friends and feeling at home in the neighborhood. What happens between when Al (Joyce) moves in and feels lonely and when he (she) ends up with many good friends?[79]

Orientation to planning and ability to plan should be assessed in students from the middle of elementary school and up. By mid–elementary school age, children learn when to plan, when not to plan, and why planning is necessary. Between ages 8 and 12 years, they elaborate that one must plan to do something, plan how to do something, and plan the specific conditions for doing something. They realize that one does not need to plan if one already knows how to do something well or if others plan for you. They also know that one must plan because there are many activities to accomplish and the activity will not work if one does not plan.[80]

Extended discourse requires that students plan, that they understand the global organization for a particular type of text, and that they be able both to "center" and "chain." For example, when given a topic to discuss or write about, they must be able to make each of their comments refer to the topic (center) and while placing each of the utterances in a logical sequence (chain). Students with ADHD are likely to have difficulty simultaneously centering and chaining in discourse. They are particularly likely to begin discussing the topic but then chain a series of associated ideas, forgetting the original topic; consequently, their narratives lack overall coherence and cohesion. Their stories tend to consist of chains of events and lack clear plans to achieve goals. SLPs should note the overall coherence (does the story make sense?) and the student's use of cohesion strategies (linguistic strategies). Table 1 gives examples of the types of cohesion to look for. Beyond third grade, students should be able to include cause and effect sequences of behaviors, goals and plans for characters,

Table 1 Examples of Cohesion

Category	Type	Examples
Conjunction	Additive	Max gave the bird some bread *and* he ate it all.
	Adversative	Max gave the bird a lot of bread, *but* the bird kept crying.
	Causal	Max helped the snail *because* he felt guilty for breaking its shell.
	Temporal	*When* Max saw the snail was hurt, he stopped to help.
Referential	Pronominal	The snail cried and cried. *He* wanted another shell.
	Demonstrative	Max gave the snail a thistle. *That* didn't work.
	Comparative	There were three pigs. *The smartest one* built her house with adobe brick.
	Lexical	
	Same word	Max got a *thistle* for a shell. The *thistle* hurt the snail's back.
	Synonym	Max was *mad* at the bird. He was *furious*.
	Superordinate	Max tried a *thistle, rose*, and a *mushroom*. None of the *plants* worked.
Impaired cohesion	Ambiguous	
	Exophoric	Max put the cheese *there*.
	Can't retrieve from text	Max picked *it* and gave *it* to the snail.
	Wrong relation	Max took the bird home *so* he liked him.
	Inappropriate voice (abrupt shift in role)	*I* like these videos. *We* see them a lot.
	Incorrect determiner	Use of ''the'' on first reference or ''a'' on second reference, e.g., Max found *the* bird. He took *a* bird home.

consequences, and a conclusion that relates back to the events at the beginning of the story.

CONCLUSION

The increasing incidence of ADHD and our changing understanding of its causes and nature places new demands and challenges on professionals working with children and adults with ADHD. Some might argue that the underlying cause of the learning difficulties that students with ADHD exhibit (executive function and WM deficits, language impairment, dyslexia and language-based reading disorders) is less important than developing and providing interventions to address the deficits. Intervention choice and planning, however, are influenced by one's beliefs. If educators and SLPs believe that the learning difficulties of students with ADHD are due primarily to attention deficits, they will fail to provide students with the most appropriate interventions. Consequently, it is important that they have an understanding of ADHD.

Language impairment appears to be a component of all types of ADHD, even the type that has been termed ADHD only. All students with ADHD, whether or not they have diagnosed comorbid reading and language disabilities, exhibit deficits in higher-order discourse. This is in accord with Barkley's[7] postulate that a core impairment in ADHD is a deficit in self-directed speech and the internalization of language used for the development of mental representation and self-regulation.

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