CHAPTER

1

Introduction and Overview

Memory is an unique psychological construct and cognitive function in that almost everyone is interested in or concerned about his or her memory at some point in life. Nearly every person, even a 4-year-old child, has a concept of memory and an awareness of how his or her memory functions. Almost everyone knows that short-term memory is limited in capacity and duration, that long-term memory has an immense capacity, and that memories can last for a lifetime. Even a young child knows that people quickly forget most information and that there are strategies that help memories endure. Nearly everyone also understands that memory is necessary for learning to occur and that personal memories define each individual. Yet, most children have misconceptions about memory and how it functions, misconceptions that can be detrimental to learning. For example, many children erroneously believe that the intention to remember something will increase the probability of later retrieval or that delayed recall will be just as strong as immediate recall. Similarly, there are disagreements about memory structure and functions among researchers and practitioners who are concerned with human memory. For example, there has been an ongoing dispute about how memories become solidified through the process of consolidation. Most of the discord arises from the fact that memory is extremely complex, consisting of several systems, with each system serving different purposes and incorporating somewhat different cognitive processes (Tulving, 1985). Indeed, memory is not a single homogenous entity but a composition of many distinct interacting brain systems (Emilien, Durlach, Antoniadis, Van Der Linden, & Maloteaux, 2004). It is only recently that neuroscientists and other researchers have begun to unravel the incredibly sophisticated mental function known as memory.

Driven by advances in neuroscience and brain imaging, the past 20 years has seen a resurgence of research on the memory functions of children and adolescents. Although many of the contemporary investigations have focused on working memory (see Dehn, 2008), a sizable portion concern long-term memory systems and processes and how they relate to academic learning. The subjects of these studies are no longer limited to children with severe acquired brain injuries. A variety of at-risk populations (see Chapter 4), as well as normal learners, have been studied. A few investigations have reported on low incidence disorders, such as developmental amnesia, while numerous studies have focused on children with more common

medical conditions, such as childhood diabetes, that can damage the hippocampus (the brain's key long-term memory structure). Also, more studies are taking place in educational environments in an attempt to understand how memory impairments affect academic learning. Furthermore, there has been an explosion of neuro–psychological research on the memory dysfunctions of adults with debilitating medical conditions, such as Alzheimer's. Although the memory problems suffered by adults are somewhat different from those experienced by youth, most of the empirical findings are applicable to children because long-term memory systems and processes are essentially in place by 6 years of age. For example, depression affects memory functioning in youth in much the same way it affects the memory functioning of adults. As the number of references in this text will attest to, there is an abundance of scientific literature on populations with memory impairments, the characteristics of memory disorders, measurement of memory, interventions, and even on instructional practices that enhance memory for what has been learned. This scientific literature, along with books like this one, allows psychologists, educators, and related professionals to more fully understand how to identify and help youth with memory problems.

The growing interest in memory has made many psychologists and related practitioners realize that there are many school–age youth with unidentified memory impairments. This realization, coupled with advances in understanding memory functions, has led to a growing demand for memory assessment instruments and to the refinement of existing measures. For example, more cognitive scales have recently added working memory subtests, and memory batteries like the Wechsler Memory Scale®-Fourth Edition (Wechsler, 2009) have incorporated the latest empirical findings about long-term memory. Despite the availability of technically adequate tools, practitioners who evaluate children and adolescents seldom conduct comprehensive assessments of memory. Consequently, many students with long-term memory dysfunctions remain unidentified or are misidentified. For example, students receiving educational services for learning disabilities are likely to have underlying memory impairments. Yet, this significant learning impediment often goes unrecognized. In addition, there are significant numbers of children and adolescents with memory problems who are never referred because they appear to be "normal" students. In the United Kingdom, Temple and Richardson (2006) screened more than 300 normal children aged 8 to 12 years for episodic and semantic memory problems. Temple and Richardson discovered that 5.8 to 5.9% of the students with average IQ had specific memory difficulties. Given that this study excluded children with below-average IQ and identified learning problems, the number of students actually suffering from memory problems may be twice as high. One reason for the under-identification is that young children rarely complain of memory problems (Middleton, 2004). Even adolescents who have had memory deficits all their lives may be unaware of their deficits. Another reason students with memory problems are not referred or identified is that their academic learning and performance problems are attributed to other causes.

Furthermore, beliefs regarding the efficacy of memory interventions and instruction may limit the number of students referred for a memory assessment, based on the belief that there's no point in identifying problems that can't be remediated. Many educators and psychologists assume that there are no scientifically based interventions for memory impairments and dysfunctions, or that such interventions cannot be applied in an educational environment. Neither assumption is true; efficacious memory interventions that can be applied in education settings are well documented in the scientific literature (see Chapters 7 and 8). Adding to the lack of identification and intervention is the No Child Left Behind and Response-to-Intervention (Brown-Chidsey & Steege, 2005) educational movements, where the emphasis is strictly on academic skills interventions. Proponents of Response-to-Intervention argue that the cognitive cause of a student's learning problems is irrelevant and that generic academic interventions will work regardless of the underlying reasons for the learning problems. Sadly, this philosophy may deprive many students of the understanding, assistance, and interventions that might allow them to succeed (Kipp & Mohr, 2008). For instance, some reading disabilities are due to long-term memory problems rather than deficient phonological processing skills. Addressing the long-term memory problems of such children will be more beneficial than additional training in phonemic awareness, a skill they already possess.

In the school environment, the rapid acquisition and long-term retention of facts and concepts is fundamental to success. The ability to rapidly and continuously process new information and store it for later recall is essential in the relentlessly demanding educational environment where a new memory may need to be created as often as once every 10 seconds (Newall & Simon, 1972). Every aspect of acquiring and applying academic skills and knowledge depends on adequately functioning long-term memory structures and processes. Reading decoding, reading comprehension, mathematics, spelling, basic writing skills, written expression, and academic subjects, such as science and social studies, all require effective encoding, storage, and retrieval of vast amounts of information. For example, progress in mathematics depends on the retention and efficient recall of basic math facts, and advances in written communication depend on remembering grammatical rules. The acquisition of academic knowledge depends on both the episodic (memory for events) and semantic (memory for facts and concepts) systems, as well as the effective functioning of memory processes, such as encoding, consolidation, and retrieval (see Chapter 2). Because many semantic memories result from the accumulation of episodic memories acquired during multiple learning events, episodic memory ability (once thought to be autobiographical only) is just as important for classroom learning as semantic memory. For example, a student's recall of the personal experiences and contextual cues stored as episodic memories can facilitate retrieval of academic knowledge stored in semantic memory (Hood & Rankin, 2005). Thus, all long-term memory systems, including the subconscious implicit memory system (see Chapter 2) play a role in academic learning and performance. Moreover, the short–term and working

memory systems are indispensible when students are committing information to memory (Dehn, 2008).

When students experience learning and memory problems in the classroom, there is often an underlying impairment, dysfunction, or inefficiency in encoding, consolidating, or retrieving information. That is, apparent long-term memory problems are seldom due to an inability to store a tremendous amount of information for long periods of time. The first potential impediment is impaired encoding, which can arise from ineffective encoding procedures or from a less than fully functional hippocampus. Encoding transfers information from short-term and working memory into long-term storage. Many times, the target information has been encoded but it is difficult to recall over time because it was not encoded in a manner that facilitates retrieval. At other times, encoding may be functioning properly but memories are not maintained because they are not integrated with related memories or are not transferred to permanent storage regions in the brain, a process known as consolidation (see Chapter 2). Difficulties retrieving information from long-term storage can also be the source of memory performance problems. In addition, poor self-awareness and self-regulation of memory functions (known as metamemory), along with the use of ineffective memory strategies, can reduce efficiencies and exacerbate minor memory problems. Also, subaverage related cognitive and executive processes, such as inhibitory control, can further complicate matters. Consequently, ferreting out the impaired processes underlying memory problems can be an assessment challenge.

MEMORY AND LEARNING

Differentiating Memory and Learning

There is no learning without memory, and there is no memory without learning. Memory, the indicator that learning has occurred, can be inferred from the ability to recall information, performance on a measure of retention, or a change in behavior. The bilateral relationship between learning and memory is not limited to directed efforts to acquire and retain facts and knowledge. Because people learn from their experiences, the interdependency of memory and learning exists any time humans are mentally processing information. Although learning and memory are tightly interwoven and often viewed as equivalent constructs, it is possible to distinguish between the two. As memory expert L. R. Squire (1987, p. 3) put it, "Learning is the process of acquiring new information, while memory refers to the persistence of learning in a state that can be revealed at a later time." In this book, a similar division of learning and memory is applied. "Learning" refers to the acquisition of knowledge; in other words, getting information into memory is considered the learning phase. Because learning depends primarily on the memory process of encoding, learning and encoding are viewed as essentially equivalent. Of course, learning

opportunities are seldom limited to a single episode. Multiple opportunities to learn mean that consolidation and retrieval processes also become involved, as initially learned information is recalled, restructured, and reinforced. Nonetheless, in this text "learning" mainly refers to the initial learning event and is mainly associated with encoding. In contrast, "memory" includes and depends on the learning (encoding) phase, but the term is mainly applied to retention processes and the ability to recall information when needed. Thus, learning refers to the initial acquisition and immediate retention of new material, as measured within seconds and minutes; whereas, memory involves retrieval of that learning after an interval of several minutes, hours, or days. Consequently, learning is associated more with short-term than with long-term memory, and memory is mainly associated with retention of learning over extended intervals of time. Evidence for the separability of learning and memory is provided by the fact that individual differences in learning do not always translate into similar differences in memory. For example, an individual who learns new material very quickly may not retain the material as well as an individual who takes longer to learn it. Furthermore, many variables that have sizable effects on the rate of learning appear to have very little, if any, effect on how long information is retained in memory (Bloom & Shuell, 1981). Consequently, it is possible to obtain substantial improvements in memory without corresponding improvements in initial learning and vice versa.

Learning Rate and Forgetting

As learning proceeds, more and more information is retained and recalled. Each round of exposure, practice, or study of new material or a new skill produces higher recall. The degree of improvement over multiple learning episodes is known as the learning rate, and plotting learning across trials produces a learning curve. Learning curves demonstrate that acquisition of new knowledge or skills increases rapidly at first but then levels off, with each subsequent round of practice, review, or study producing smaller and smaller improvements in performance (Anderson, 2000). Despite diminishing improvements, the old adage that "practice makes perfect" definitely holds true for learning and memory: Recall of information improves the more it is practiced. Even after a learner has reached 100% recall of the material, further practice improves memory, as indicated by faster retrieval speed. Moreover, with each round of practice, the skill or knowledge is relearned more quickly, indicating that memory for the material is becoming stronger and stronger. Although most skills and knowledge eventually become ingrained in memory after numerous rounds of practice, rehearsal, review, or study, there are scientifically based learning and encoding methods that can improve the efficiency and effectiveness of learning (see Chapters 7 and 8). For example, strategies that involve in-depth processing of information produce better recall than rote learning. Given the fact that most students do not engage in enough study to fully master material, strategies that enhance learning and memorability are definitely advantageous. For students with

memory problems, the application of effective strategies becomes even more important.

According to classical learning theory, a faster learning rate translates into slower forgetting, and slower learning is connected with faster forgetting. However, for many students, learning rate and forgetting rate may actually have a weak and inconsistent relationship (Brainerd & Reyna, 1995). In fact, Shuell and Keppel (1970) reported only minimal differences between fast and slow learners' rates of forgetting. Thus, assumptions about retention of information should not be based on rate of learning. Some individuals are fast, and apparently successful, learners but don't retain new learning very well. Others are slow learners but successfully retain what they have acquired. Instead of initial learning speed, the number of additional learning events required to fully retain material may be a better predictor of forgetting rate. A potential confound when examining these relationships is the fact that students who learn more slowly are usually provided with more learning opportunities. The fact that learning opportunities increase as learning rate decreases may compensate for the faster forgetting rates among slow learners (Brainerd & Reyna, 1995).

One of the goals of education is for students to retain important knowledge and skills for a lifetime. When learning is effective, students with normal memory functioning are capable of just that. In studies of very long-term retention of academic knowledge (reviewed in Cohen, 2008a), a prominent finding is that the level of original learning predicts the degree of retention. That is, students who initially learned more, mastered the material, or acquired more advanced knowledge, remembered more over extended periods of time. Other factors that influence long-term retention include the amount and spacing of the original training, the level of expertise originally attained (grades being one method of determining this), and the extent to which the information can be reconstructed from schemas. In one study of Spanish language retention, individuals who had not used Spanish during their lifetime were tested 50 years after initially studying it. Amazingly, 40% of the original knowledge could still be recalled and 60% of it was recognized (Bahrick, 1984). These longitudinal studies reveal that knowledge declines exponentially for about three to six years and then stabilizes before a final slight decline after 30 years.

MEMORY PROBLEMS

As used in this book, the term "memory problems" is used in a generic, inclusive sense. Memory problems exist whenever an individual has significantly subaverage ability in one or more aspects of memory, as indicated by subaverage performance on a formal measure of memory, difficulties performing tasks that require effective memory functioning, or difficulties retaining scholastic learning at a normal level. Memory problems are especially indicated when the subaverage performance or difficulty is also a significant intra-individual weakness relative to overall learning potential or intelligence. Thus, memory problems include memory weaknesses,

impairments, deficits, disorders, dysfunctions, and deficiencies (see Chapter 3 for further clarification). It is presumed that there is either a neurological impairment underlying the memory problem or ineffectual use of normal memory capabilities. Memory problems in children and adolescents become worthy of concern, and assessment and intervention, when they either impede academic learning or impair daily functioning.

Because memory problems cover a continuum from mild to severe, they can be much more than minor inconveniences. In extreme cases, such as global amnesia, the individual may have difficulty coping with daily routines. In children and adolescents, even mild to moderate memory problems can impair many types of learning, leading to lifelong limitations. For example, a verbal memory impairment in a young child will affect the development of language and literacy. However, even significant memory problems can be difficult to detect and identify, leading to some assessment and diagnostic challenges. For example, not all memory problems are evident during early childhood. Most tend not to become apparent until learning challenges are encountered during the school years. Even then they are likely to be attributed to other factors. Also, many memory problems are subtle, which is why they are misunderstood. Subtlety, however, does not mean that the memory problems are not interfering with the effective learning and functioning of otherwise normal individuals. Nor does subtlety obviate the need for investigation, evaluation, and appropriate interventions and instruction. Educators and psychological practitioners need to remember that subtle or mild memory problems have an additive effect during the educational years, with the end result being fewer acquired skills, less knowledge, and failure to achieve important life goals.

Memory problems and their undesirable consequences may occur even when there is no underlying memory impairment. There are times when problems with encoding, storing, and retrieving information are not due specifically to abnormalities in the brain's memory structures. What is observed as a limitation in one or more memory structures or functions may actually stem from a broader cognitive disability or from a domain-specific impairment. For example, a child or adolescent with a general intellectual impairment is unlikely to demonstrate average memory performance. Also, individuals with a general verbal processing disability, such as those with a language impairment, are typically going to have weaknesses in any type of verbal memory function. Separating memory functions from the influences of related cognitive processes should be attempted during assessment, but whether or not poor memory performance is part of a broader cognitive disability is somewhat irrelevant. The fact is that students with cognitive disabilities benefit from memory interventions and memory-based instruction as much as students with intra-individual memory deficits. Therefore, those with cognitive disabilities also should be considered as having memory problems and provided with appropriate services. Finally, there is another group of children and adolescents whose subaverage memory performance is due to neither cognitive processing limitations nor specific memory impairments. These are youth with otherwise normal cognitive and memory abilities

who have not yet figured out how to effectively utilize their memory capabilities due to delayed metamemory development or failure to apply effective strategies. In this book, they are also classified as having memory problems.

APPLYING MEMORY RESEARCH IN THE CLASSROOM

For decades, research by experimental, cognitive, and educational psychologists, as well as neuropsychologists and neuroscientists has documented the efficacy of numerous memory interventions, strategies, mnemonics, and instructional practices. Yet, many of these evidence-based practices have not been consistently applied in the classroom, an environment that continually places high demands on memory. The lack of application originates with teacher training programs that pay little attention to psychological research on memory and the educational applications of memory research. Consequently, relevant empirical findings and evidence-based practices have had very little influence on pedagogy and instructional practices in the classroom. Although effective teacher behaviors and evidence-based instructional practices generally support memory functioning (Rosenshine, 1995), approaches that specifically address memory functions can further enhance the academic learning and performance of all students (see Chapter 8). Teachers who address memory challenges, teach memory strategies and mnemonics, and adopt more instructional practices that specifically support memory, may ultimately reduce their burdens rather than adding to them, mainly because memory-based methods should increase the efficiency of student learning. Even students recognize the benefits of memory-based instruction. For instance, Scruggs and Mastropieri (1990) reported that the learning disabled students in their study greatly preferred memory-based instruction over traditional instruction. In reality, classroom-based memory interventions may be the only viable approach to serving the needs of students with memory impairments, as the funds, resources, and personnel available for pull-out services is very limited. Accordingly, one of the primary objectives of this book is to provide educational consultants, school psychologists, special education teachers, and classroom teachers with all of the information they need to successfully implement evidence-based memory practices in the classroom.

OVERVIEW OF THE CHAPTERS

Chapter 2, *Memory Systems and Processes*, describes and differentiates the functions of the major memory systems, the types of memory that comprise each system, and the memory processes involved. After discussing the structure, organization, and interrelationships of short-term, working, and long-term memory, the focus shifts to the two major divisions of explicit memory—episodic and semantic—and the primary long-term memory processes: encoding, consolidation, and retrieval. Following an

explanation of the interdependency of episodic and semantic memory, the pivotal role of consolidation in the formation of enduring semantic memories is proposed. Essentially, the chapter provides a comprehensive review of theories and research about human memory. The chapter concludes with implications for the assessment and intervention topics addressed in subsequent chapters.

Chapter 3, *Memory Neuroanatomy, Development, and Dysfunction*, examines memory from a neuropsychological perspective, as opposed to the cognitive perspective in Chapter 2. The neuroanatomy section describes how memories are formed through synaptic changes and strengthening, as well as alterations in neural pathways that connect related networks of neurons spread throughout the brain. The focus is on the medial temporal lobe and hippocampus, the two most critical brain structures in the encoding, consolidation, and retrieval of long-term memories. The section on development of long-term memory includes an in–depth discussion of metamemory and the vital role it plays in developing the child's ability to remember more and more information. The chapter concludes with a discussion of memory dysfunctions, such as amnesia, that can impair learning and daily functioning.

Chapter 4, *Risk Factors for Memory Impairments*, is potentially the most interesting and alarming chapter in this text because it reviews the memory research on approximately 30 disorders and medical conditions that place children at–risk for memory impairments. For example, the hippocampus of children with poorly controlled diabetes can suffer irreparable damage from repeated hypoglycemic episodes. The review attempts to identify specific memory components and processes that are most likely to be affected by each risk factor, leading to identification of specific memory components that should be addressed during assessment and intervention when a child or adolescent has experienced one of these risk factors.

Chapter 5, *Long-Term Memory Assessment Strategies*, promotes a hypothesis-driven approach to comprehensive memory assessment that incorporates selective, cross–battery procedures. The chapter begins with the identification of and rationale for specific memory components that should be considered for testing. In addition to standardized testing, the chapter details informal assessment procedures, including sample items for interviews and observation. The recommended assessment strategies are unique in that the assessment of metamemory development, strategy use, and classroom examination performance is included. The chapter concludes with a case study that illustrates clinical analysis procedures for identifying intra–individual weaknesses and deficits.

Chapter 6, *Assessing Long-Term Memory with Standardized Tests*, critically examines memory batteries and memory subtests from cognitive scales that are suitable for testing the memory functions of children and adolescents. For each memory scale reviewed, there is information on the structure, technical properties, and general interpretative procedures, followed by a brief critique of the scale. For each long-term memory subtest included, there is a description of the task, identification of the specific memory components it measures, and interpretative suggestions, along with implications of low performance. To facilitate selective, cross–battery testing, the

chapter includes tables that identify the specific memory components tapped by subtests from several memory and cognitive scales.

Chapter 7, *Interventions for Memory Problems*, guides the reader through a step-by-step approach to selecting interventions, setting goals, measuring progress, and general training procedures for strategies. After confronting the challenges and concerns regarding memory interventions, there is an emphasis on metamemory training and demonstrating the efficacy of strategies and mnemonics. Then the details needed for implementation are provided for several evidence-based memory strategies and mnemonics, followed by an overview of non-strategic interventions, such as memory aids. Following a discussion of special methods recommended for children with traumatic brain injury, the chapter concludes with the typical sequence and activities recommended for a one-on-one intervention with a child or adolescent who has mild to moderate memory problems.

Chapter 8, *Classroom Instruction That Supports Memory*, focuses on instructional practices that enhance the memory functioning of students, especially those with memory problems. Underlying the recommendations in this chapter is the presumption that these instructional practices and the teaching of memory strategies will be most successful in a classroom that is oriented towards supporting the memory of learners, an environment and approach referred to as the "mnemonic classroom." The chapter, written with teachers and educational consultants in mind, includes details for evidence-based instructional practices that can easily be incorporated in the classroom. For each of the recommended practices and memory strategies, there is a discussion regarding what it is, how it works, why it works, who it benefits, the research supporting it, and how to apply it in the classroom. The chapter concludes with tips for reducing working memory load in the classroom and a summary of key memory principles that apply to classroom instruction.

Chapter 9, *Case Studies and Recommendations*, integrates many of the ideas discussed throughout the book by illustrating how memory impairments might be manifested in children's behavior and learning. In addition to providing all the assessment details about two cases introduced earlier in the book, the chapter relates everything that occurred during the actual intervention sessions with a 13-year-old student. In addition, student comments, reflections, and plans are reported from another intervention case. The chapter concludes with recommendations for future research and memory test development.

LEARNING OBJECTIVES

After reading, studying, and applying the information and practices discussed in this book, the reader will be able to:

1. Describe the unique characteristics of and key differences among short-term, working, and long-term memory systems.

2. Delineate the functions of episodic and semantic memory and the interdependency between them.
3. Explain the roles of encoding, consolidation, and retrieval on the formation, retention, and recollection of memories.
4. Envision the creation, strengthening, and interconnectivity of memories at the cellular and neural network levels.
5. Unequivocally understand the crucial role of the hippocampus in the encoding and consolidation of episodic and semantic memories.
6. Describe various aspects of metamemory and how a well-developed metamemory can enhance memory functions.
7. Explain how comparing performance on uncued recall tasks with performance on recognition tasks helps to determine whether a retention or a retrieval problem underlies difficulty recalling information.
8. Recognize more than two dozen medical conditions and disorders that place children and adolescents at-risk for memory impairments.
9. Plan a comprehensive, but efficient assessment of memory and related processes that addresses the referral concerns.
10. Complete informal memory assessment procedures that include interviews, observations, and an evaluation of metamemory development.
11. Properly analyze and interpret test scores derived from a cross-battery assessment.
12. Given a variety of memory and cognitive scales, select appropriate subtests for the measurement of specific memory components.
13. Given a child or adolescent with mild to moderate memory problems, select appropriate evidence-based strategies, mnemonics, and other methods.
14. Convincingly illustrate the efficacy of memory strategies and mnemonics while conducting an intervention.
15. Provide training that promotes the development of metamemory self-awareness and self-regulation.
16. Recognize the procedures and rationale for memory interventions reserved for students with severe memory impairments, such as those who have suffered a severe traumatic brain injury.
17. Effectively consult with classroom teachers about evidence-based instructional practices that enhance students' encoding, consolidation, and retention of learning.
18. Provide the rationale for teaching evidence-based memory strategies and mnemonics in the classroom.
19. Understand many of the intricacies that will need to be incorporated if a one-on-one intervention with a student is to succeed.
20. Structure and write an evaluation report about an examinee's memory functions that is understandable to all readers.