**Chapter 4: Memory Systems**

**Learning Objectives**

* Understand the three-store theory of memory and the behavioral and neurological evidence supporting it.
* Describe the different duration and capacity characteristics of sensory, short-term, and long-term memory.
* Distinguish between anterograde amnesia and retrograde amnesia.
* Describe the functions of working memory according to the multicomponent model.
* Compare and contrast the multicomponent model with the embedded-process model of working memory.

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**Brief Summary**

Memory is our capacity for retaining information over periods of time ranging from immediate events to events experienced in the distant past. It is typically divided into three separate storage systems: Sensory memory, short-term memory, and long-term memory. These three storage systems are supported by three mental processes: Encoding, storage, and retrieval. These processes contribute to the formation of mental representations and also operate on them. The three memory systems are considered to be dissociated or separate from one another. Evidence for this dissociation comes from studies of serial position effects in which memory retention depends, respectively, on the location of items in an ordered series with the initial items and the final items being remembered best. Memory for the initial items is considered to reflect the influence of long-term memory and memory for the final items is considered to reflect the influence of short-term memory. Neurological evidence for the dissociation of short-term and long-term memory comes from studies of amnesia with retrograde amnesia reflecting memory loss for information previously stored in long-term memory and anterograde amnesia reflecting an inability to store current information in short-term memory.

Working memory is a subsystem of short-term memory for temporally maintaining mental representations that are relevant to the performance of a cognitive task in an activated state. It consists of multiple components which are specialized for processing specific types of information. The phonological loop is specialized for processing and storing verbal information, whereas the visual-spatial sketchpad is specialized for processing and storing nonverbal information. A third component, the episodic buffer, is specialized for integrating event representations. The central executive allocates attentional resources to control processing in these three stores. An alternative view, the embedded-process model, considers short-term memory to be an activated subset of long-term memory and is supported by neuroimaging studies identifying activation in the left-and right-hemisphere that is correlated, respectively, with verbal and visual working memory.

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**Detailed Summary**

1. The three-store model of memory distinguishes among sensory, short-term, and long-term stores. This highly influential model sought to identify unique characteristics within each store. The efforts proved successful with regard to capacity and duration but less so with regard to coding, forgetting, and retrieval. The capacity of short-term memory is limited to about four chunks of information, and its duration is less than 30 seconds. The capacity limits of long-term memory are unknown, and its duration is measured in decades.

2. The hippocampus plays a critical role in storing events in long-term memory. The hippocampus, a structure in the medial temporal lobe of the brain, binds together neural activity from locations distributed across the neocortex during learning. Until an event is consolidated in long-term memory, the hippocampus is needed to index the locations of the distributed memory representation. Damage to the hippocampus causes severe anterograde amnesia, meaning that recent new events cannot be stored in long-term memory.

3. Free recall of a list of words reveals a serial position effect. The last items in the list are recalled first and well—the recency effect. The initial items in the list are also recalled well—the primacy effect. The three-store model attributes the recency effect to the short-term store and attributes the primacy effect to the long-term store*.* The model also accounts for evidence from patients suffering from anterograde and retrograde amnesia and from reduced short-term memory capacity.

4. Working memory refers to the system for temporarily maintaining mental representations that are relevant to the performance of a cognitive task in an activated state. It involves short-term memory stores plus attentional control over processing in a cognitive task. The multiple-component model postulates stores for verbal information, called the phonological loop; nonverbal information, called the visual-spatial sketch pad; and integrated event representations, called the episodic buffer. The central executive controls processing in these short-term stores. A competing alternative is the embedded-process model, which regards short-term memory as the activated subset of long-term memory. Both models make similar predictions. For example, neuroimaging research shows that verbal working memory is supported by regions in the left hemisphere. Visual or object-based working memory and spatial or location-based working memory are supported by separate regions in the right hemisphere. These distinct neocortical regions could be the activated subset of long-term memory or separate short-term stores dissociated from long-term memory.

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**Topical Outline**

Sensory Memory

Sensory memory holds incoming sensory stimuli for a brief period of time and functions to permit stimuli to be perceived, recognized, and entered in short-term memory.

Iconic Memory

* Visual sensory memory is called iconic memory. Iconic memory has a large capacity and a brief duration of about 250 milliseconds.
* Sperling (1960) pioneered the study of iconic memory using the whole and partial report techniques.

Echoic Memory

* Auditory sensory memory is called echoic memory. It is similar to iconic memory in that it possesses a large capacity, but has a longer duration, about 2 seconds.

Short-term Versus Long-term Memory

* Researchers, beginning with William James, have distinguished between short-term memory or memory for immediate events and long-term memory or memory for previously stored information.

Serial Position Effects

* Recall of a list of items conforms to a pattern based on the serial position of the items. Greater recall accuracy is observed for the initial items on the list, known as the primacy effect, and the final items on the list, known as the recency effect. The middle items on the list are typically forgotten.
* The primacy effect is attributed to the influence of long-term memory and the recency effect is attributed to the influence of short-term memory.

Neurological Dissociations

* Evidence from patients suffering from anterograde amnesia, retrograde amnesia, and reduced short-term memory capacity supports the distinction between short-term and long-term memory.
* Anterograde amnesia refers to difficulty remembering new information or information encountered after the onset of amnesia. This is considered to reflect a disruption of the transfer of information from short-term to long-term memory.
* Retrograde amnesia refers to the loss of previously stored information or information that occurred prior to the onset of amnesia. This is considered to reflect a disruption in long-term memory.
* Neuroanatomical studies of brain damage in amnesics have identified the hippocampus as an important structure in the storage of information in long-term memory. The hippocampus is also considered to play a role in binding together the features of a memory.
* Researchers have debated whether the neural representation of a memory is localized in a particular brain area or distributed across multiple brain regions.

Consolidation

* The process of successfully storing an event in long-term memory so that its representation is strengthened for later recall. Subsequent to consolidation, retrieval from long-term memory can proceed without hippocampal involvement.

Retrograde Amnesia

* The temporal extent of retrograde amnesia can provide an understanding of how long the consolidation process takes to complete.

Impaired Short-Term Memory

* Neuropsychological evidence indicates short-term memory impairments, particularly for auditory information.

Capacity

* The results of digit span tests indicate that human short-term memory capacity is limited to about seven digits.
* Short-term memory capacity can be increased through chunking or regrouping large amounts of meaningful information into smaller units.
* Human short-term memory capacity is limited to about four chunks of information.

Duration

* The duration of human short-term memory is less than 30 seconds.

Other Distinguishing Criteria

Coding

* + The phonemic similarity effect refers to the high rate of intrusion errors in short-term memory for stimuli that are pronounced alike.
  + Dual-coding theory holds that information is best remembered when it is stored in long-term memory using both verbal and imaginal codes.

Forgetting

* Proactive interference is when past learning interferes with the ability to learn and remember new information.
* Retroactive interference is when recent learning interferes with the recall of previous learning.

Retrieval

* The memory search process can occur serially, one item at a time, or in parallel, with all items in memory being examined simultaneously.
* A self-terminating search is when the memory search terminates upon locating the target information, whereas an exhaustive search is one that continues to examine the remaining items in memory even after the target item has been found.

Working Memory

* The memory system that functions to temporarily maintain mental representations that are relevant to the performance of a cognitive task in an activated state.

Multiple Component Model

* Working memory includes components for transiently storing phonological or verbal features, visual features, spatial locations, and integrated episodes. It also includes an executive attentional component for controlling access to the stores.

Embedded Process Model

* Short-term memory is considered to be a currently and transiently activated subset of long-term memory. The current focus of attention is a process embedded within activated short-term memory.

Conclusion

* Working memory is a system that provides temporal and spatial continuity between the experiences of our past and our present actions.

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**Key Terms**

iconic memory

echoic memory

serial position effect

primacy effect

recency effect

anterograde amnesia

retrograde amnesia

consolidation

chunking

dual-coding theory

phonemic similarity effect

proactive interference

retroactive interference

serial search

parallel search

self-terminating search

exhaustive search

working memory

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**Discussion Questions**

Discussion Question #1

Explain how serial position effects elucidate the different contributions of short-term and long-term memory to the retention of information. How are these different contributions to serial position effects supported by neurological evidence?

Discussion Question #2

Explain how the processes of binding and consolidation are related. What role does the hippocampus play in each of these processes? Describe how these processes provide an understanding of the differences between short-term and long-term memory.

Discussion Question #3

Explain the differences between the basic memory processes of encoding, storage, and retrieval. What are some of the ways these processes can fail?

Discussion Question #4

What is the relationship between attention and memory? How does Baddeley’s working memory model account for this relationship?

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**Questions for Thought**

What is your earliest childhood memory? How old were you when the event occurred? Why do we often fail to remember events from the first few years of life?

Severe alcohol intoxication can cause blackouts, whereby experienced events are not adequately stored in long-term memory. Although the intoxicated person appears to be cognizant of events as they happen, he can possess only fragmentary or no recollection of them the morning after. Explain this phenomenon in terms of the three-store model and functioning of the hippocampus.

How do you use working memory in everyday tasks? Explain how long-term memory aids performance of these tasks in contrast to working memory.

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**Web Resources**

[**Astound Demonstrations**](http://courses.missouristate.edu/timothybender/mem/mydemos.html#astound)

An interactive demonstration based on Waugh and Norman’s (1965) retroactive interference study.

[**Sternbeg’s STM Scan Demo**](http://www.cogs.indiana.edu/software/STMScanJ2/index.html)

An interactive demonstration of Sternbeg’s short-term memory scanning experiment.

[**Instructions for the Serial Position Experiment**](http://psych.hanover.edu./JavaTest/CLE/Cognition/Cognition/serialposition_instructions.html)

An interactive demonstration of the serial position effect.

[**Working Memory Capacity**](http://www.gocognitive.net/demo/working-memory-capacity)

An interactive demonstration of working memory capacity using digits, shapes, and math problems as stimuli.

[**Cognitive Tests: Working Memory Test**](http://cognitivefun.net/test/4)

An interactive demonstration of the n-back task.

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**SAGE Journal Articles**

Roediger III, H.L. & Wertsch, J.V. (2008). [Creating a new discipline of memory studies](http://mss.sagepub.com/cgi/reprint/1/1/9?ijkey=m1IudnRDVcMFA&keytype=ref&siteid=spmss)*.* Memory Studies, 1, 9-22.

1. According to the authors, what are the core disciplines of a new field of memory studies? How does the use of memory in a discipline such as literature differ from its use in psychology?
2. What methodological and theoretical challenges exist for the emerging field of memory studies?
3. Washington University has created a two-year program, “Memory in Mind and Culture.” What are the courses that comprise this program and what topics do they cover?

Petty, R.E., Tormala, Z.L., Hawkins, C., & Wegener, D.T. (2001). [Motivation to think and order effects in persuasion: The moderating role of chunking](http://psp.sagepub.com/cgi/reprint/27/3/332?ijkey=CXaLI49vKLEuc&keytype=ref&siteid=sppsp)*.* Personality and Social Psychology Bulletin, 27, 332-344.

1. In their article, the authors discuss the effects of primacy and recency effects on the impact a message has on the susceptibility of individuals to persuasion. Based on the design of their study, in which messages are presented to participants, what do the authors consider to be a primacy effect? What do they consider to be a recency effect?
2. How are the primacy and recency effects in persuasive messages different from the primacy and recency effects in serial recall of items on a list? How are they the same?
3. What role do the authors’ consider chunking to have in how individuals evaluate messages?

Kirby, K.C., Montgomery, I.M., Badcock, R., Daniels, B.A. (1995). [*A comparison of age-related deficits in memory and frontal lobe function following oral lorazepam administration*](http://jop.sagepub.com/cgi/reprint/9/4/319?ijkey=jm/nNsEb5GQ.s&keytype=ref&siteid=spjop)*.* Journal of Psychopharmacology, 9, 319-325.

1. According to the authors, what cognitive abilities tend to show impairment with increasing age?
2. The authors note that lorazepam, a drug known to produce temporary amnesia, has differential effects on old and young people. What are some of the effects reported by the authors?
3. Although damage to the hippocampus is generally associated with the development of amnesia, the present paper suggests that the frontal lobe can also play a role in amnesia. In particular, the authors point out that frontal lobe dysfunction is associated with a particular form of amnesia known as Korsakoff’s amnesia. Based on the information in the paper, how does Korsakoff’s amnesia differ from amnesia caused by damage to the hippocampus?
4. The authors report that lorazepam did not have any effect on non-verbal memory based on the performance of participants on the Rey Figure task. How does this agree with Baddeley’s theory of working memory?

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**Recommended Readings**

Baddeley, A. (1986). *Working memory*. New York: Oxford University Press.

Baddeley, A. D.(2001). Is working memory still working? *American Psychologist, 56,* 849–864.

Gabrieli, J. D. E. (1997). Cognitive neuroscience of human memory. *Annual Review of Psychology*, 49, 87-115.

McDaniel, M. A., & Einstein, G. O. (2007). *Prospective memory: An overview and synthesis of an emerging field*. Thousand Oaks, CA: Sage Publications.

Schacter, D. L. (2001). *The seven sins of memory: How the mind forgets and remembers.* Boston: Houghton Mifflin.

Thompson, R. F. (2005). In search of memory traces. *Annual Review of Psychology*, 56, 1-23.