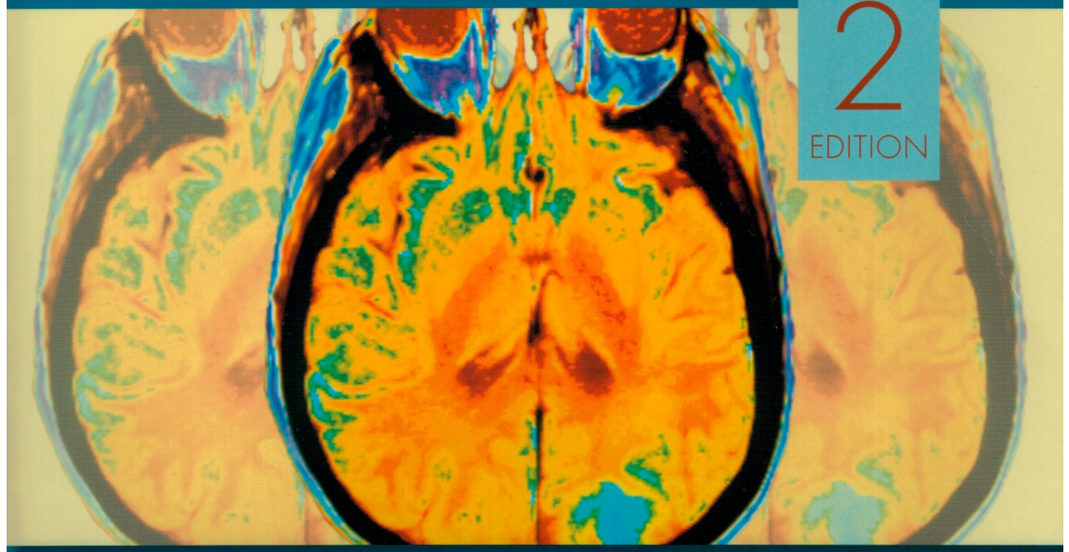
FUNDAMENTALS OF COGNITIVE PSYCHOLOGY

2 EDITION



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CHAPTER 5

Remembering Events

So far in this book, long-term memory has been described as if it were unitary. In the coming chapters, multiple systems of long-term memory are differentiated and described. Consider, for a moment, everything you need to know to be able to drive a car. You need to know what a car looks like, what a steering wheel does, and what the functions are of the two or three pedals on the floor, among other things. You need to know the rules of the road, the meaning of traffic signs, and the purpose of the solid and dashed lines on the streets. You further need several perceptual, motor, and cognitive skills to start the vehicle, put it in gear, steer, brake, and navigate your way to a destination. How does remembering any of this impressive array of knowledge depend on being able to recall the events that took place around you 5 minutes ago? Or events that were stored in long-term memory 5 or even 50 years ago? It turns out that long-term memory for such knowledge can be preserved even when memory for past events is severely impaired. Long-term memory seems to be partitioned into different systems that can function or fail independently of one another.

The present chapter considers how new events are learned, that is, how they are encoded and stored in long-term memory. Much is known about the operations that support the learning of new events. Next, the processes involved in retrieving or failing to retrieve events from long-term memory are discussed. Finally, the manner in which retrieval cues enable the recollection of past episodes is addressed. Forgetting occurs when the available retrieval cues fail to activate available, but inaccessible, event representations. However, before beginning a detailed discussion of how events are remembered, the different types of long-term memory must be defined.

TYPES OF LONG-TERM MEMORY

Just as working memory involves more than one component, long-term memory does not appear to be unitary. Scholars disagree about the criteria that must be satisfied to conclude that there are multiple systems of long-term memory. Mathematical models, and related computer simulations, begin with the assumption that the fewer systems of memory, the

better. Not only is a single long-term store a more parsimonious explanation of memory phenomena, but it surely is easier to model with the necessary precision of mathematics (Hintzman, 1990). The danger with the mathematical perspective is it overlooks the messy nature of biological organisms in the search for an elegant computer simulation.

From the perspective of evolutionary biology, however, fewer and better need not coincide at all. Different systems evolve precisely because they afford successful adaptations to the challenges posed by the environment. Just as with other characteristics of an organism, a novel system of memory shown by a subpopulation of a species will come to dominate if it aids, in some fashion, survival and reproduction. A separate memory system evolves when the functions of existing systems fail to meet the demands of a new environmental challenge (Sherry & Schacter, 1987). The danger with the biological perspective lies in needlessly cluttering our theories with a separate memory system for each seemingly separate memory phenomenon. The evidence favoring multiple systems is presented next, followed by some criticisms of how such evidence has been interpreted.

Declarative Versus Procedural Memory

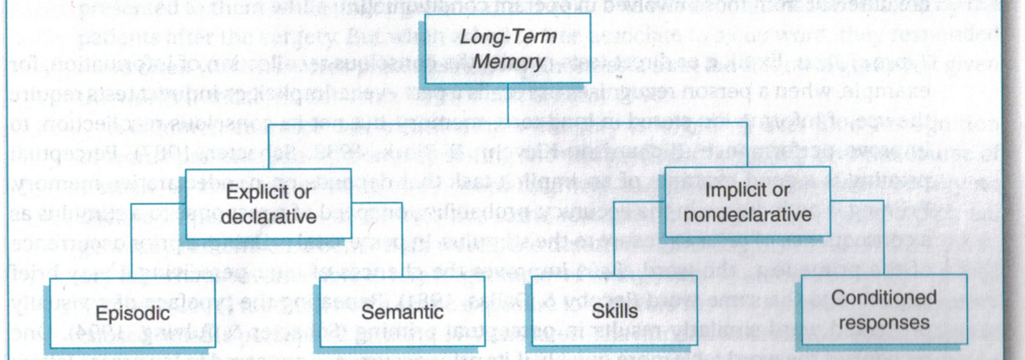
Philosophers have distinguished between declarative and procedural knowledge—knowing *what* versus knowing *how*. Knowing the rules and traditions of baseball is not the same as being able to play baseball. Knowing how is often tacit or unconscious, whereas knowing what is explicit or conscious. As shown in Figure 5.1, memory theorists have proposed that the long-term memory store be divided into two major systems: declarative and procedural (e.g., Tulving, 1985; Zola-Morgan & Squire, 1990).

Declarative memory refers to knowledge of events, facts, and concepts, in short, knowing what the world presents to us. Declarative memory is sometimes referred to as explicit memory because one is consciously aware of the kinds of mental representations involved. It is possible to gain informational access to these representations and, in some cases, report on them verbally. In other cases, they are coded as images that are difficult to verbalize but are consciously accessible nonetheless.

As shown in Figure 5.1, declarative memory, in turn, consists of two components. **Semantic memory** stores knowledge of concepts and facts. Knowing what a baseball is reflects conceptual knowledge. Knowing that Andre Pujols often hit baseballs over the outfield fence for a home run when he played for the St. Louis Cardinals is factual knowledge stored in semantic memory. However, a memory of actually witnessing a home run by Andre Pujols during a particular game at a particular place and time is a memory of an event. Episodic memory refers to the recollection of events that took place at specific places and times in the past. Unlike semantic memory, the context of the memory is encoded in terms of visual-spatial and temporal relations.

Procedural or **nondeclarative memory** refers to the skills and conditioned responses that reflect knowing how to respond to the world. Procedural memory is sometimes called implicit memory because it uses mental representations that are not accessible to conscious reflection. Motor skills, such as running and typing, are familiar to all. One's body knows how to run or type without the mind being consciously aware of the representations that do the work. In fact, attempting to become consciously aware of the steps involved in

Figure 5.1 Hierarchical memory system: Types of long-term memory.



a motor skill, such as one's tennis stroke or golf swing, can disrupt procedural memory. Thinking about it only gets in the way.

Not all skills are motor. Perceptual skills such as reading or appreciating the visual arts are also part of procedural memory. So, too, are highly cognitive skills such as writing or problem solving. In fact, procedural memory involves other kinds of behaviors in addition to motor, perceptual, and cognitive skills, such as conditioned responses (see Figure 5.1). A stimulus in the environment triggers a learned response, and this, too, is a form of procedural memory. Conditioned responses can be learned through operant conditioning, in which a response is associated with a stimulus by using rewards. A conditioned response can also be stored in procedural memory as a result of classical conditioning, in which a conditioned stimulus is associated with an unconditioned stimulus. For example, a classically conditioned fear response to lightning (conditioned stimulus) might develop because the thunder (unconditioned stimulus) that follows lightning automatically elicits fear (unconditioned response).

It appears that the different kinds of long-term memory are supported by different brain structures (Squire, 1992). For example, it is well established that the procedural memory pathways needed for classical conditioning of skeletal muscles are found in the cerebellum rather than in the hippocampal system used in the conscious recollection of events from episodic memory (R. F. Thompson, 2000). Furthermore, a rapidly growing body of research uses positron emission tomography (PET), functional magnetic resonance imaging (fMRI), and lesion studies to isolate different brain regions for different kinds of nondeclarative memory. Learning sensorimotor skills (e.g., tracing a figure viewed in a mirror), perceptual skills

Long-term memory is made up of multiple memory systems. A major division in the hierarchy of these systems is the distinction between declarative memory (knowing what) and nondeclarative memory (knowing how).

(e.g., reading mirror-imaged text), and cognitive skills (e.g., solving problems) each involves a different neural substrate. Furthermore, the brain regions that mediate classical conditioning are different from those involved in operant conditioning.

Types of Tests. Explicit or direct tests require the conscious recollection of information, for example, when a person recognizes or recalls a past event. Implicit or indirect tests require the use of information stored in long-term memory, but not its conscious recollection, to improve performance (Richardson-Klavehn & Bjork, 1988; Schacter, 1987). Perceptual priming is a good example of an implicit task that depends on nondeclarative memory. Priming is an increase in the accuracy, probability, or speed of a response to a stimulus as a consequence of prior exposure to the stimulus. In perceptual priming, a prior occurrence of the prime (e.g., the word *chair*) improves the chances of later perceiving a very brief exposure to the same word (Jacoby & Dallas, 1981). Repeating the typeface of a visually presented word similarly results in perceptual priming (Schacter & Tulving, 1994). One recognizes the word *table* more quickly if its prior occurrence appeared in lowercase letters (table) than if it appeared in uppercase letters (TABLE). Neuroimaging methods indicate that regions just outside the primary visual cortex in the occipital lobe support this kind of nondeclarative memory (Buckner, Goodman, et al., 1998).

Interpreting Test Dissociations. Tulving and Schacter (1990) argued that dissociations on implicit and explicit tests support the multiple-system viewpoint. To illustrate, one variable is the use of normal versus amnesic individuals. Amnesic patients forget recent or past episodic events, yet they still show priming effects right along with normal individuals (Graf, Squire, & Mandler, 1984; Shimamura, 1986). Warrington and Weiskrantz (1970) pioneered the use of a word completion test to reveal normal priming effects in amnesics. They first presented a printed list of words and tested the ability of amnesic and normal individuals to recall and recognize them correctly. They also asked the participants to complete a word fragment (cha___) with the first English word that came to mind. If *chair* appeared on the original study list and the individual completed the fragment as *chair*, then priming had occurred. Although the amnesic patients failed badly at recall and recognition, priming on word completion showed no decrement.

Milner (1965) discovered that "H. M." could learn how to trace the outline of a shape while looking in a mirror rather than at the shape. Such motor skill learning remained intact despite the anterograde amnesia for episodic events caused by H. M.'s brain surgery. Learning perceptual skills also may be preserved in amnesic patients (Moscovitch, 1982), as may learning a classically conditioned response (Weiskrantz & Warrington, 1979). When a flash of light is emitted just prior to the onset of a puff of air to the eye, both normal and amnesic individuals acquire a conditioned eye blink response to the presentation of the light alone. Although the amnesic patients retained the conditioned response on a test 24 hours later, they had no conscious recollection of having gone through the conditioning experiment only 10 minutes after it was completed.

Drug-induced dissociations between implicit and explicit memory tests have also been documented. Drugs such as alcohol and scopolamine can produce amnesia for episodes that occurred during the altered state of consciousness. Despite this amnesia, the drugs leave unimpaired performance on implicit tests of procedural nondeclarative memory

(Hashtroudi, Parker, DeLisi, Wyatt, & Mutter, 1984; Nissen, Knopman, & Schacter, 1987). Some controversial evidence even suggests that patients show priming effects for words presented to them while under general anesthesia. The words could not be recalled by the patients after the surgery. But when asked to free associate to a cue word, they responded more often with the words presented during anesthesia than did a control group not given the words (Kihlstrom, Schacter, Cork, Hunt, & Bahr, 1990).

A common characteristic of declarative memory is forgetting over time. Recognition of words presented in a laboratory setting shows significant forgetting over the course of 1 week. By contrast, priming in the word-fragment completion task showed virtually no decline in performance at all over this same retention interval. For pictures, which are generally remembered better than words, the duration of priming in nondeclarative memory is perhaps invulnerable to any forgetting over many years. In an extraordinary finding, Mitchell (2006) reported that a single exposure to a picture for 1–3 seconds in a laboratory caused reliable perceptual priming 17 years later! The implicit test required participants to identify a picture from seeing only fragments of it, similar to the word-stem completion task. Picture-fragment identification was more accurate for those who had briefly seen the picture once years in the past than for those for whom the picture was novel.

Episodic Versus Semantic Memory

To summarize (Figure 5.1), declarative memory consists of two subcomponents: remembering events and knowing facts and concepts (Tulving, 1985). Episodic memory concerns the recollection of events that took place at specific places and times in the past. Semantic memory concerns factual and conceptual knowledge about the world and the words used to symbolize such knowledge. Such memory makes no reference to specific episodes in time and space. Suppose that you spot a bicycle on campus. Recognizing the two-wheeled object as a member of a category illustrates the use of semantic memory; the concept and the word used to refer to the object are activated. If you begin to think about the properties of bicycles in general (e.g., they have two wheels, a seat, and handlebars), then you are still using semantic memory. If, however, you begin to recall the bicycle you received on your sixth birthday, then you are using episodic memory. The specific memories you have of learning to ride it and the accidents you had with it are episodic memories located at places and moments in the past.

Episodic memory is a specifically dated occurrence of an event in a particular context. Semantic memory refers to factual and conceptual knowledge about the world. They are subsets of declarative memory.

The anterograde amnesia case presented earlier in the chapter shows that episodic and semantic memory can be dissociated. H. M. showed a profound inability to store new episodic memories in long-term memory. However, his general knowledge of the world and his verbal abilities were not at all impaired. Intelligence tests provide a way to assess factual and conceptual knowledge along with word meanings. H. M. scored very well on an intelligence test, recording an IQ of 112, where 100 is an average score (Milner, 1966).

Unlike H. M., most of us have the ability to store events from our lives in episodic memory and to retrieve those events later with reasonable accuracy. However, a highly unusual case of extraordinary episodic memory of autobiographical events has been discovered (Parker, Cahill, & McGaugh, 2006). For a woman identified as A. J., recollections of the past intrude on her daily existence in an uncontrolled manner. She spends large amounts of time recalling her past in great detail. For example, if given a date from, say, 15 years ago, A. J. can report what she was doing that day and the day of the week on which the date fell. She does this without using mnemonic techniques to improve encoding events into episodic memory (mnemonic techniques will be discussed later in this chapter). She does keep a diary to record her daily activities, but so do many others who do not show such a syndrome of heightened episodic memory.

Whereas A. J. experiences exceptionally detailed episodic memory, another case study reveals a stunning total absence of autobiographical recollection of a personal past (Tulving, 2002). K. C. suffered serious head injuries at the age of 30 from a motorcycle accident; the medial temporal lobes were damaged along with other regions of his brain. As with H. M. and other amnesics, K. C. showed little if any impairment in his general intelligence and language abilities. He could read, write, and play chess and card games, and he retained his ability to play the organ. Like H. M., he suffered from severe anterograde amnesia and could not learn new episodic or semantic information. However, K. C. also suffered from a highly asymmetric form of retrograde amnesia. He could not recollect any personally experienced events from his past, even things that had happened on more than one occasion. Even so, his semantic knowledge was for the most part intact. His general knowledge of the world as well as his knowledge of history, geography, mathematics, and other things learned in school was fine. Oddly, he knew many semantic facts about his life, such as his date of birth, his childhood home address, and the names of schools he had attended. Despite this intact semantic memory, he could not recollect any specific personal events or situations from his past. K. C. denied any sense of recollection of the past even when provided with extensive, specific information about events that had been part of his life. The most he could recall about his personal past was what had occurred a minute or two ago.

Another form of evidence in support of the distinction between episodic and semantic forms of declarative memory comes from the dissociation of two kinds of judgments made on a recall test. Participants are asked to make judgments about whether they know an event occurred in the past or whether they remember its occurrence (Rajaram & Roediger, 1997). *Remembering* means having recollections of personal experiences from the past through mental time travel; that is, taking the self back in time to relive specific episodes. Thus, when you recall the day you graduated from high school, you can mentally travel back in time and recollect particular events, people, and interactions involving you personally. *Knowing* refers to being aware of facts and concepts in the absence of personally reliving past experiences. Knowing can take the form of a feeling of familiarity about abstract concepts or of being aware that past events happened without the mental time travel of re-experiencing them. You may, for example, know that a speech was made at commencement exercises, but recollecting the speech, or the face or name of the speaker, might not be possible. Knowing reflects retrieval from semantic memory.

Consider an experiment in which participants are given a list of words and then a recognition test is administered. Half of the items on the test are new and half are old. For each item the participants decide is old, they then introspect about the conscious experience associated with this decision and indicate whether they remember the item or simply know that it was on the list. Tulving (1985) introduced this procedure in an effort to measure episodic memory directly with "remember" judgments and to measure semantic memory with "know" judgments.

It turns out that remembering and knowing judgments are affected differently by variables that influence memory. For example, if an item is repeated in a list several times in succession, then the number of "know" responses is high. However, if the repetitions are spaced out so that several items intervene between each repetition, then the number of "remember" responses is high (Parkin & Russo, 1993). As another example, alcohol (Curran & Hildebrandt, 1999) and the antianxiety drugs called benzodiazepines (Bishop & Curran, 1999) reduce the number of "remember" judgments given to old items on a recognition test. But the drugs have no effect on the "know" responses. If one assumes that "remember" judgments reflect episodic memory, whereas "know" judgments reflect semantic memory, then such dissociations strengthen the case for a separation of episodic and semantic memory (Gardiner & Richardson-Klavehn, 2000).

Criticisms of Multiple Systems

Although there is growing evidence in favor of multiple systems of long-term memory, challenges have been raised to the hypothesis. Different processes operating on a single declarative memory system can also give rise to dissociations (Hintzman, 1990; Jacoby, 1983; Johnson & Hasher, 1987; Roediger, 1984). For example, Roediger and Blaxton (1987) observed that learners often initiate top-down or conceptually driven processes, such as focusing on ways to organize new information. Bottom-up or data-driven processes are forced by the stimuli or data themselves, such as whether the modality of presentation was auditory or visual. It may be that implicit tests, such as perceptual priming, are more affected by data-driven processes, whereas explicit tests depend more on conceptually driven processes. Thinking about the meaning of stimuli during their encoding, as opposed to their perceptual appearance, could affect only explicit tests because such a difference in the level of encoding influences the functioning of conceptually driven processes but not data-driven processes. Perhaps amnesic patients demonstrate priming effects in a word-completion task because such priming reflects data-driven perceptual processes.

Jacoby (1991) further observed that the implicit tests of memory are not pure measures of nondeclarative memory. It is possible that one recollects having seen a prime earlier in the task, and so part of the facilitation could reflect episodic memory. Nor are explicit tests a pure measure of only episodic memory. For example, on a recognition test, one might call an item "old" because it seems vaguely familiar rather than remember it as having actually been on the study list. When an individual intends to recollect an event and experiences a subjective awareness of remembering, consciously controlled processes are at work. Automatic processes of familiarity from past exposure can influence memory without intention or awareness.

To illustrate, Jacoby, Woloshyn, and Kelley (1989) demonstrated that familiarity with a name from a recent past exposure can automatically cause one to categorize the name as

famous even though it is unknown. Participants are first read a list of names, while they either give the names full attention or divide their attention with another task. Next, they are asked to judge whether the names on a second list are famous or not. Some of these names are famous, and some are nonfamous. Some of the nonfamous names are repetitions of names heard in the first part of the experiment. When distracted in the divided attention condition, participants were likely to mistakenly think that repeated nonfamous names were, in fact, famous. One brief and relatively unattended exposure was all it took to trigger an automatic influence on memory.

These are important criticisms of the view that long-term memory consists of multiple systems. Still, it is unclear whether the processing point of view can accommodate all of the data now available (Gabrieli, 1998; Schacter, Wagner, & Buckner, 2000). Consequently, the terms *semantic declarative memory* and *episodic declarative memory* are used in the remainder of the book and are contrasted with different kinds of nondeclarative memory.

PROSPECTIVE MEMORY

Thus far, episodic memory has been treated as system for recollecting events from the past. Tulving (2002) hypothesized that this same system provides the means for envisioning future events. It does so by retrieving relevant past memories and then embellishing these into plausible scenarios of the future. **Mental time travel** refers to the capacity for recollecting past events and envisioning future events through reconstructive retrieval processes. The default network identified in Chapter 1 works together with the superior occipital gyrus to construct a visual-spatial context for experiencing a past or a future personal event (Schacter, Addis, & Buckner, 2007). The hippocampal region of the brain in the medial temporal lobe is crucial for retrieving the temporal and visual-spatial relations of events. Together with posterior regions of the parietal cortex and the medial prefrontal cortex, fragments of past episodes appear to be combined into a simulation of what might occur in the future. Unlike other cognitive processes identified with the default network, such as moral reasoning, mental time travel requires the occipital cortex to visualize the remembered or imagined event. Although Tulving (2002) viewed mental time travel as the function of episodic memory, semantic memory may also contribute general knowledge about the properties of events and help to guide the construction of future scenarios (Schacter et al.).

One study asked participants to remember a specific past event, such as a birthday party, or to imagine the same event occurring in the future (Szpunar, Watson, & McDermott, 2007). The superior occipital gyrus, together with the default network of the medial temporal lobe, the posterior midline region of the parietal lobe, and the medial prefrontal cortex, were showed as having heightened fMRI activation for both the past and the future events. These regions were far less active when the participants imagined events involving a famous person, Bill Clinton, rather than the self. Even though Bill Clinton was a familiar concept in semantic memory and easy to envision, the network for simulating personal events was not relied upon in envisioning Bill Clinton at a birthday party. Similarly, Szpunar, Chan, and McDermott (2009) found that the mental time travel network was

activated for envisioning a personal event in a familiar setting (e.g., the library) but not in an unfamiliar one (e.g., a bull fight). To summarize, the mental time travel network involves the occipital lobe together with the brain's default network to construct our autobiographical past and future.

Thinking about the future is a highly adaptive function of memory. On a daily basis, we are confronted with the need to remember to take some action in the future. Examples include remembering to go to class on time, remembering to meet with friends at a specific place and time this coming weekend, remembering to keep an appointment with a doctor or dentist, and remembering to take medications according to an exacting schedule. **Prospective memory** is defined as remembering to take some action at a specific time in the future (McDaniel & Einstein, 2007). It involves a plan or intention to do something at a relatively distant point in the future as opposed to immediately. Prospective memory is embedded in ongoing daily activities that demand attention. Thus, it is not usually possible to simply keep the intention to act in the focus of attention. Finally, everyday prospective memory provides a limited window of opportunity for initiating and completing the intended action. For example, the intention to pick up a child after school implies a window of several minutes in which the action must be taken. By contrast, an intention to pick up a prescription at the pharmacy allows a time frame of several hours. A failure of prospective memory can entail either forgetting the relevant time frame or forgetting the intention to act altogether.

How, then, do people remember to perform an action in the future? One possibility is that they continuously monitor for cues to take action. R. E. Smith (2003) had research participants make lexical decisions about whether letter strings presented on a continuous basis were either words (e.g., *river*) or nonwords (e.g., *rovul*). As a prospective memory task, they were asked to detect if the words matched any one of six predetermined targets. If monitoring for the targets consumed limited attention, then the lexical decision task should be slower. In fact, Smith observed lexical decision was 300 milliseconds slower when engaged in prospective memory than when target detection was not embedded in with the lexical decision task. Monitoring puts one into an effortful retrieval mode to remember to act at the appropriate time. From a mental time travel perspective, one is always thinking about a specific future action.

Einstein and McDaniel (2005) observed that monitoring, while effective, is also costly to ongoing activities. They also observed that some participants in prospective memory tasks verbally reported that the intention to act just popped into mind at the moment needed. Because delays between forming intentions and the time frame when they must be carried out are often lengthy—days or even weeks—in everyday circumstances, focusing attention on continuous monitoring for opportunities to act as planned would seem maladaptive. A less effortful, spontaneous means of retrieval would avoid relying exclusively on monitoring. Several studies reported by Einstein and McDaniel showed that spontaneous retrieval provides another process by which to achieve prospective memory. It comes into play when attention is focused on the prospective memory target. For example, with only a single target word as opposed to six possible target words, lexical decision time was not slowed by a concurrent prospective memory task, and the target was correctly detected 86% of the time.

ENCODING AND STORING EVENTS

The three-store model assumes that encoding and storing events in long-term memory involves rehearsal. The nature of the rehearsal processes brought into play at encoding is critical, as suggested by Craik and Lockhart (1972). **Maintenance rehearsal** refers to recycling information within short-term or working memory by covertly verbalizing it. **Elaborative rehearsal** refers to linking information in short-term memory with information already stored in long-term memory. Elaborative rehearsal can take many forms. Organizing items into categories, associating items with other known information, and forming visual or auditory images of the items are examples of elaborative rehearsal. For instance, as noted in Chapter 4, it is easier to remember a list of words if one visualizes the object to which each word refers in addition to encoding the sound of the word itself (Paivio, 1971, 1983). Imagery works better for concrete objects that can readily be visualized (e.g., elephant) than for abstract concepts (e.g., gravity).

Mnemonic techniques designed to improve memory generally rely on elaborative encoding in the form of visual images (Bower, 1972; McDaniel & Pressley, 1987). Imagery has been recognized as crucial to memory from the time of the ancient Greeks. Cicero recounted a story about the Greek poet Simonides, who delivered a long poem at a Roman banquet. On finishing, Simonides left the building just moments before catastrophe struck. The building collapsed, burying everyone in the rubble. According to the legend, Simonides was able to survey the ruins and recall the names of the victims by first imagining where they had been seated.

The mnemonic called the method of loci (places) consists of identifying a sequence of familiar locations and then forming an image of each item to be remembered at each of the locations. Once a clear image is formed, the locations provide a plan for retrieving the items. By imagining a walk to each of the locations in the sequence, one can remember the items (Bower, 1970). A demonstration of the method of loci is presented in Box 5.1.

Box 5.1 A Demonstration of the Method of Loci

The method of loci is a mnemonic technique that uses familiar locations as an aid to memory. To illustrate, first picture a sequence of 10 locations at home or on campus that you know well. Now, try to form an image with each of the following grocery items, placing one item at each location in order. For example, for the first item, you might imagine a banana peel on the front steps of your home. Try to create a distinctive image for each item and location.

Bananas	Olives
Lettuce	Bread
Crackers	Hamburger
Bacon	Tuna
Milk	Mustard

Now, close the book and try to recall the items by taking a mental walk to each of the 10 locations. Most people find it much easier to remember the 10 items when using this imaginal technique than when simply rehearsing the items repetitively using maintenance rehearsal. Recall from Chapter 4 how difficult it was to retain more than seven or so chunks of information. Yet, most people find it easy to recall all 10 items using the method of loci, a type of elaborative rehearsal.

Maintenance rehearsal refers to recycling information within short-term or working memory by covertly verbalizing it. Elaborative rehearsal refers to transferring information to long-term memory by linking it with information already stored there.

One reason for the superior recall produced by the method of loci and related techniques is that mental images provide a second code, in addition to the word itself, for the memory system (Paivio, 1971, 1983). Without forming a mental image of the words to be remembered, one is left with only a verbal code. Further investigation of imagery and mnemonics suggests that the imagery makes an event in memory more distinctive and, hence, easier to recall (Marschark, Richman, Yuille, & Hunt, 1987; McDaniel & Einstein, 1986). Mnemonics also benefit memory by providing a set of retrieval cues that match the cues encoded with the to-be-remembered material (Bower, 1970). Taking a mental walk with the method of loci is a retrieval plan as well as an encoding plan. Each location visited at the time of retrieval allows one to reconstruct the event originally stored there with relative ease.

Craik and Lockhart (1972) made the strong claim that only elaborative rehearsal results in permanent long-term learning because of the need to analyze broadly and deeply the features of the stimulus. Because maintenance rehearsal merely recycles items in working memory, it presumably does not result in improved recall. Although early experiments supported this claim (Craik & Watkins, 1973), it became clear through further research that maintenance rehearsal helps memory some, albeit much less than does elaborative rehearsal (Darley & Glass, 1975; Greene, 1987).

Levels of Processing

In Chapter 2, we examined how sensory and semantic features are analyzed during pattern recognition. Data-driven and conceptually driven processes rapidly and accurately identify the objects, events, and symbols of our environment. These perceptual processes operate automatically when attention is devoted to a stimulus and occur to some degree even when the stimulus is unattended. In memory research, **levels or depths of processing** refers to a memory superiority for events attentively processed at a semantic level as compared with a sensory level.

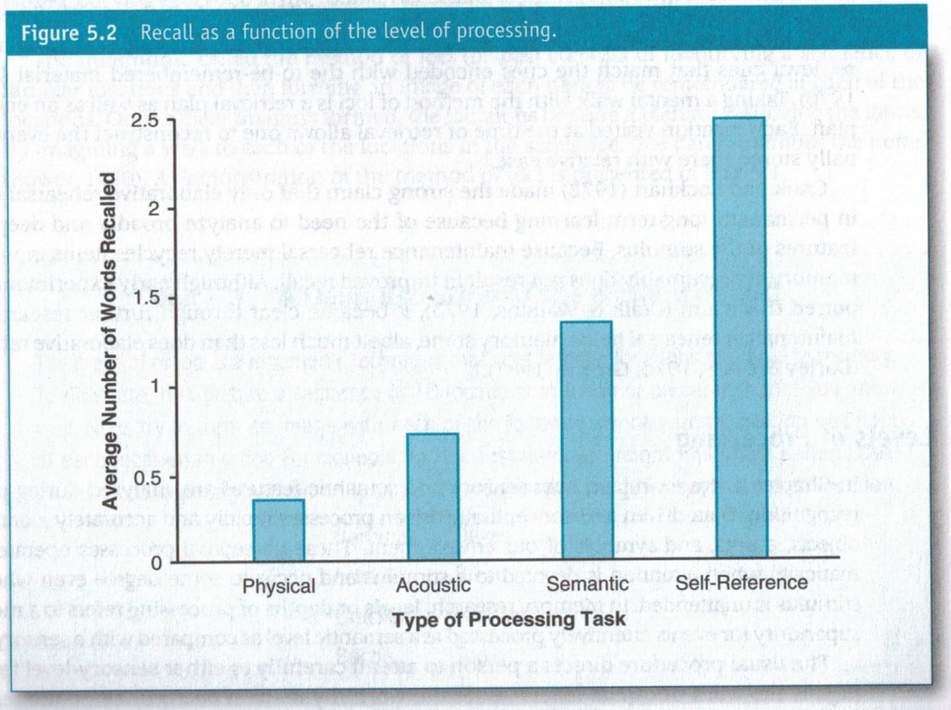
The usual procedure directs a person to attend carefully to either sensory-level features (e.g., Is the word in capital letters? Does the word rhyme with *blue*?) or semantic features (e.g., Does the word fit the sentence "He slipped on his _____"?). In answering these

orienting questions about the word *shoe*, the focus of attention would be visual, acoustic, or semantic features. These three conditions reflect increasing levels or depths of processing. Recognition or recall of the target words is then tested. The results showed that visual and acoustic encoding is inferior to semantic encoding on memory tests (Craik & Lockhart, 1972). Craik and Tulving (1975) interpreted this level of processing difference in terms of elaborative rehearsal. Semantic encoding produced a more elaborate representation of the target words in memory, which supported superior recall and recognition.

Is there an orienting task that produces maximal elaboration and memory? Some research suggests that processing the information in relation to our self-concept is superior, a finding called the **self-reference effect.** Rogers, Kuiper, and Kirker (1977) found that when people asked whether a word applied to themselves (e.g., *ambitious*), later recall rose above that obtained for even the semantic-orienting task. The recall results for physical, acoustic, semantic, and self-reference levels of processing are shown in Figure 5.2. Of interest, the same outcome occurs when people make judgments about consumer products shown in advertisements (D'Ydewalle, Delhaye, & Goessens, 1985). Answering the question "Have you ever used this product?" supported greater recall of brand names than did a semantic-orienting task. Other evidence indicates that the key ingredient in this effect involves relating the information to highly developed representations in long-term memory, providing many links with well-ingrained information (Bellezza, 1986).

Levels or depths of processing refer to a memory superiority for events attentively processed at a semantic level as compared with a sensory level. Processing events semantically in reference to one's self-concept results in particularly strong memory.

Figure 5.2 Recall as a function of the level of processing.



SOURCE: Adapted from Rogers, Kuiper, & Kirker, (1977).

Recent findings suggest that self-reference may not be the single most effective way to encode a list of words. Nairne, Thompson, and Pandeirada (2007) proposed that long-term memory may have evolved in the ancestral past of human beings to retain information relevant to survival. Study participants were asked to pretend that they were stranded in the grasslands of a foreign country, without supplies needed for survival. They then rated the words presented in a list for their relevance to finding a source of food and water and to protecting them from predators. This survival-orienting task was then compared to a deep-encoding task that invokes emotional reactions to words (ratings of how pleasant the words are to the person) and to the self-reference task. A surprise-free recall test of the rated words showed an advantage for the survival processing compared with both the pleasantness and self-reference task. These results are intriguing and suggest that further examination of the adaptive function of long-term memory and its evolutionary origins is a promising direction for future research.

Transfer-Appropriate Processing

The principle of **transfer-appropriate processing** holds that test performance hinges on engaging in an encoding process that is compatible with the demands of the test. For example, different kinds of studying may be called for depending on the nature of the test. Practice at generating and organizing ideas would be a highly appropriate way to prepare for an essay test, but such preparation might transfer less well to a multiple-choice test.

Morris, Bransford, and Franks (1977) found that the typical levels of processing effect can be reversed by picking a test that is appropriate to visual- or acoustic-orienting tasks. They showed that the overlap between encoding and retrieval processes mattered more than the nature of encoding per se. For example, in one condition, participants were tested for recognition of words based on whether they rhymed with a word presented earlier, rather than on recognition of the identity of the word, as is typical. The authors found that rhyme encoding supported better rhyme recognition than did semantic encoding. Because rhyme encoding is appropriate for the rhyme-retrieval test, it transfers better than semantic encoding. The fact remains, however, that recalling or recognizing an event depends critically on its meaning—its semantic features. Because remembering an event requires the retrieval of semantic information, it is semantic encoding that transfers well to standard recall and recognition tests.

Distinctiveness

Plainly, the extent to which one stores information in an elaborate manner predicts how well it will be remembered. But why should elaboration have this effect? One part of the answer is that elaborative rehearsal results in learning the distinctive features of items (Hunt & Einstein, 1981; Hunt & McDaniel, 1993). **Distinctiveness** refers to how the items to be learned are different from each other and other items already stored in memory.

A highly distinctive representation is one that can be discriminated easily at the time of retrieval. The more the item stands out in memory, the easier it is to find.

Suppose that you are asked to memorize a list of nonsense syllables and one odd item: a number. People rarely forget the isolated distinctive number, an effect named after its German discoverer, von Restorff, and described in English by Koffka (1935). The power of distinctiveness can be seen in Eysenck's (1979) variation on the levels of processing effect, in which he compared sensory- versus semantic-orienting tasks. His sensory task entailed attending to the sounds of words. In a distinctive encoding condition, Eysenck used unusual pronunciations of the words designed to produce a highly distinctive, albeit sensory, level of processing. Because the unique pronunciations stood out in memory, they were remembered just as well as the words processed with a semantic focus. Typically, semantic encoding produces greater elaboration, which in turn increases the likelihood of storing a distinctive code. Eysenck's finding shows that it is distinctiveness per se that ultimately matters.

Picture Memory. It has long been known that people can recognize with a high degree of accuracy a long series of complex pictures, even if they have viewed each picture in the series for only a few seconds. People can discriminate old pictures from new ones nearly perfectly when there are hundreds (Shepard, 1967) or even thousands of pictures (Standing, 1973). The reason seems to be that the pictures used in these studies contained many highly distinctive features, allowing observers to discriminate one from another. However, suppose that you must discriminate a picture of a particular $20 bill from a thousand other such pictures. When the pictures all relate to the same schema, there is no distinctiveness and so recognition suffers (Mandler & Ritchey, 1977; Nickerson & Adams, 1979). This point is revisited after a discussion of the role of schemas in retrieval.

Flashbulb Memories. An especially intriguing phenomenon may also shed light on the power of distinctiveness. A **flashbulb memory** is a vivid recollection of some autobiographical event that carries with it strong emotional reactions (Brown & Kulik, 1977; Pillemer, 1984). Depending on your age, you might be able to recall clearly exactly what you were doing, seeing, hearing, and feeling on receiving the news that President Kennedy was assassinated in 1963, that an attempt was made on the life of President Reagan in 1981, that the space shuttle *Challenger* exploded in 1986, or that the World Trade Center was destroyed by a terrorist attack in 2001. As Pillemer (1984) noted, "images of only a tiny subset of specific episodes—death of a loved one, landing a first job, getting married, hearing about public tragedies—persist over a lifetime, with little subjectively experienced loss of clarity" (p. 64). One explanation for why flashbulb memories are so well recalled is that they are highly distinctive events in long-term memory (McCloskey, Wible, & Cohen, 1988).

Some researchers have challenged whether so-called flashbulb memories are really more accurate than normal memories. For example, 2½ years after the *Challenger* explosion, participants in one study confidently recalled many details about the incident, but many of these recollections were inaccurate (Neisser & Harsch, 1992). Similarly, memories of the terrorist attack of September 11, 2001, have not proven to be more accurate than memories of nonemotional events occurring about the same time (Talarico & Rubin, 2003). Others, however, have confirmed that flashbulb memories can, indeed, be real for many people so long as the precipitating events had strong personal impacts on them (e.g., Conway et al., 1994).

A recent comprehensive study of 3,000 people from seven cities in the United States examined memories of 9/11 1 week, 11 months, or 35 months after the attack. The results seemed to resolve the controversy (Hirst et al., 2009). The study concluded that the rate of forgetting for flashbulb memories is similar to the rate of forgetting for normal memories regarding details of the event; both slowed after a 1 year. During the 1st year, the loss rate was 20% or more, but thereafter the loss rate fell to only 5%–10%. In other words, episodic memory for the event—whether it was a flashbulb recollection or not—stabilized after a year. This finding indicates that, although the two kinds of recollections differ in vividness, they both are mediated by the same memory system. Further, the investigation revealed that the strong emotional reactions of flashbulb memories do not hold up well over time; nonemotional features such as where one learned about the attack are retained better than emotional features. Thus, it appears that the flashbulb phenomenon supports neither distinctiveness nor emotion as predictors of powerfully accurate recollection.

One brain mechanism that facilitates the storage of emotionally charged information resides in the amygdala (Phelps, 2006). This is a known fact about memory encoding and storage, despite the fact that flashbulb events do not appear to invoke the mechanism as once suspected. Neuroimaging studies have shown that the degree of activation of the amygdala during encoding is predictive of how well emotional stimuli are later remembered. The most likely explanation of this phenomenon is that the emotional arousal causes the amygdala to hasten the process of consolidation in the hippocampus. This is known because of careful studies using animal models that demonstrate how the amygdala modulates processing in the nearby hippocampal region of the limbic system (McGaugh, 2004). Events that have a powerful emotional impact on an individual are treated differently during the storage process. But the relation between emotion and memory storage is not a simple one, and the next chapter will return to this topic in the context of memory distortions. For example, an eyewitness to a crime is often under severe emotional duress that has a complex effect on episodic memory.

Distinctive memory representations can be discriminated from other related memories. Strong recognition of distinctive pictures, and possibly flashbulb memories, illustrate the power of distinctiveness in enhancing memory.

Synesthesia. A bizarre demonstration of the power of distinctive encoding came from a famous case study. Over a period of 20 years, Luria (1968) studied the memory abilities of an individual referred to as "S." He tested S.'s memory span for a variety of materials and found it remarkable and seemingly without limit. In Luria's words,

> I gave S. a series of words, then numbers, then letters, reading them to him slowly or presenting them in written form. He read or listened attentively and then repeated the material exactly as it had been presented. I increased the number of elements in each series, giving him as many as thirty, fifty, or even seventy words or numbers, but this, too, presented no problem to him.
>
> The experiment indicated that he could reproduce a series in reverse order—from the end to the beginning—just as simply as from start to finish; that he

could readily tell me which word followed another in a series, or reproduce the word which happened to precede the one I'd name. He would pause for a minute, as though searching for the word, but immediately after would be able to answer my question and generally made no mistakes. . . . It was of no consequence to him whether the series I gave him contained meaning words or nonsense syllables, numbers or sounds; whether they were presented orally or in writing. . . . As the experimenter, I soon found myself in a state verging on utter confusion. An increase in the length of the series led to no noticeable increase in difficulty for S., and I simply had to admit that the capacity of his memory *had no distinct limits*; that I had been unable to perform what one would think was the simplest task a psychologist can do: measure the capacity of an individual's memory. (pp. 9–11)

Further testing only compounded Luria's (1968) confusion, for it turned out that the duration of S.'s memory, as well as its capacity, seemed to have no limit. Some tests revealed error-free recall of word lists presented 15 years earlier! Moreover, S. could recall the context in which a list had been presented, describing the place in which Luria had read him the words, the chair in which Luria had sat, and even the clothes Luria had worn.

From early childhood, S. had experienced *synesthesia*, or cross-talk among sensory modalities such that sounds, for example, were experienced visually as well as aurally. Normal individuals experience mild degrees of synesthesia in that colors are reliably associated with specific pitches of sounds (Marks, 1987). The bright colors of yellow and white elicit high pitches, whereas the dark colors of black and brown echo low pitches. But S. experienced an extreme form in which tones and noises would be apprehended as "puffs" and "splashes" of color. He would perceive the "color" of a speaker's voice, and each speech sound assumed a visual "form" with its own "color" and "taste." Plainly, these images added a unique distinctive code to memory.

Relational Processing

Clearly, then, learning how items to be remembered differ from each other is critical for good memory. **Relational processing** refers to how the items to be learned are related to each other and to other items stored in memory (Hunt & Einstein, 1981; Hunt & McDaniel, 1993). Instead of detecting differences, relational processing looks for similarities. It has long been known that well-organized information is better remembered. A learner must discover the relations among items or, when none is apparent, create his or her own subjective relations.

Category Cues. Tulving and Pearlstone (1966) showed the power of organization in their comparison of free and cued recall. The participants studied a list of 48 words that came from several categories, such as tools, fruits, and vehicles. The words occurred in a random order, but the learners noticed the organization of the items nonetheless (see Bousfield, 1953). When asked to recall as many words as possible with no hints or cues (free recall), the participants clustered related items together, for example, apples, oranges, and grapes. More interestingly, if the participants remembered a single item from a category, then they likely remembered most of the others. Conversely, if they forgot an item, such as "truck," then the other examples of vehicles also were forgotten. In other words, the category served to organize their recall.

But only about a third of the words were remembered in free recall. Tulving and Pearlstone (1966) also provided some participants with the category names as retrieval cues. Remarkably, the cues roughly doubled the number of words successfully recalled. This result for cued recall shows the powerful effect of organization as an aid to retrieval. It also shows that events may be available in memory but inaccessible to recollection without the right retrieval cues. More is said about retrieval cues later in the chapter.

Subjective Organization. The tendency to cluster items from the same semantic category is, perhaps, not surprising. Yet organization plays a critical role in recall even when a clear basis for it is lacking. Tulving (1962) presented people with lists of unrelated words and tracked their free recall over a series of trials. As participants studied the words and attempted to recall them in whatever order they wished, each participant adopted a consistent pattern of output. That is, each person imposed a **subjective organization** on the words, recalling clusters of items in the same manner trial after trial, even though the clusters themselves were purely idiosyncratic. The more categories people used in organizing the study items, the better they did on both recall tests and delayed recognition tests (Mandler, Pearlstone, & Koopmans, 1969).

Organization (ie., encoding the relations among events and prior knowledge) benefits both learning and remembering. First, the events may be chunked together during their storage (Mandler, 1979). Just as finding meaningful groupings increases learning on tests of short-term memory, the same effect may be seen in long-term memory. Second, organization provides retrieval cues that are vital to remembering (Tulving & Pearlstone, 1966). The categories imposed by the materials or by the learner serve as highly effective retrieval cues.

Subjective organization refers to the way individuals impose an idiosyncratic organizational scheme on unrelated items to be remembered.

RETRIEVAL PROCESSES

Forgetting may be caused by an inability to retrieve information that is available in memory. Such forgetting may reflect a temporary or even permanent lack of accessibility of information. This could arise because of interference from similar competing information stored in memory or because of a failure to activate the retrieval cues associated with the forgotten information. Contemporary research has focused on the cue-dependent nature of remembering and forgetting. It has emphasized how the context and knowledge related to material in memory play pivotal roles in successful retrieval.

To illustrate, recalling an event from episodic memory, such as one's 10th birthday party, requires retrieval of the time, the place, and the circumstances of stored information. Retrieval can be an active process of reimagining the perceptions, the feelings, and possibly the thoughts about the event and its context. Being provided with a cue, such as a photograph taken at the party, can trigger a chain of recollections that at first seemed lost from

memory. The cue activates related knowledge in long-term memory that eventually allows one to retrieve, or perhaps reconstruct, the needed information. What one knows about birthday parties in general affects both how one's 10th birthday party was encoded and how it will be retrieved later.

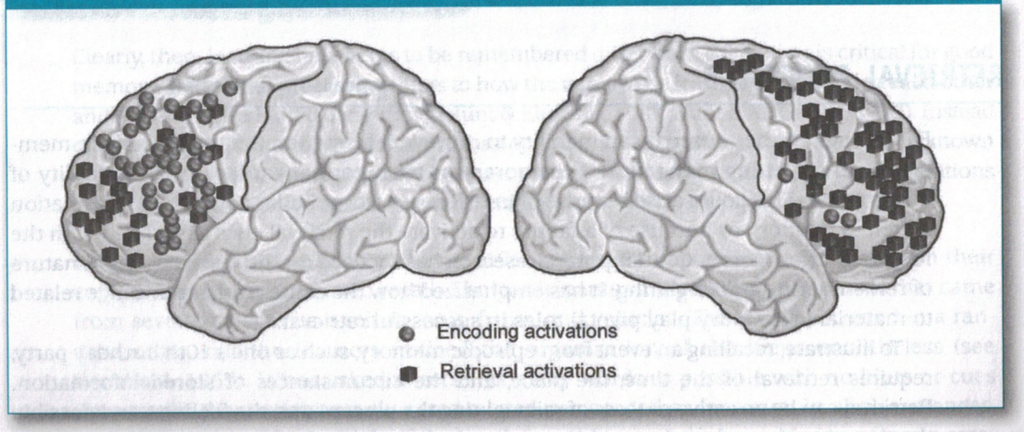
Retrieval Mode

Retrieval involves at least two kinds of subprocesses (Moscovitch, 1992). On the one hand, there are the general operations involved in attempting to remember an event, and these are observable regardless of whether the search is successful. The effort to retrieve has been referred to as **retrieval mode.** On the other hand, there are the operations specifically associated with successful recovery of the event.

Several studies with PET and fMRI have shown that a region in the anterior prefrontal cortex of the right hemisphere is activated when an effort is made to retrieve an event (Buckner, 1996). This is not the only area activated, but it is the best understood to date. For example, as seen in Color Plate 5 in the section of color plates, strong PET activation can be observed in the right hemisphere in temporal regions in addition to prefrontal regions when recollecting a highly emotional episode from more than a year in the past (Fink, et al. 1996). In contrast to the right prefrontal and other regions activated in episodic retrieval, prefrontal regions in the left hemisphere are highly activated during the encoding of events into episodic memory. These activation sites are summarized in Figure 5.3. Tulving, Kapur, Craik, Moscovitch, and Houle (1994) proposed the hemispheric encoding/retrieval asymmetry (HERA) model to account for the neuroimaging findings.

It has been difficult to say for certain whether the right prefrontal activation genuinely reflects a retrieval mode as opposed to successful recovery because of limitations in the

Figure 5.3 Different regions of the left and right prefrontal cortex are involved in episodic encoding and retrieval.



SOURCE: Adapted from Nyberg, L., & Cabeza, R. (2000). Brain imaging of memory. In E. Tulving & F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 501–519). Reprinted with permission of Oxford University Press.

scanning procedures (Schacter, Wagner, & Buckner, 2000). Researchers had to compare scans from one group of trials in which retrieval was usually successful group of trials in which forgetting was likely, to scans from another so the data were noisy. However, new fMRI procedures allow comparisons of scans for individual items on a recognition test. By comparing correct hits on old items (retrieval mode plus retrieval success) versus correct rejections of new items (retrieval mode only), the issue can be resolved. The data from such studies show convincingly similar activation levels in the right anterior prefrontal cortex for both hits and correct rejections (Buckner, Koutstaal, et al., 1998). Thus, the activation observed there is unrelated to retrieval success.

Neuroimaging evidence has identified numerous regions of the brain that appear to be activated when events are successfully retrieved from long-term memory. Different locations are observed depending on whether the events recollected are verbal or nonverbal in nature (Nyberg & Cabeza, 2000). The wide distribution across all lobes of the cortex in both hemispheres is to be expected, given that the representation of an event is distributed by its features, as discussed in Chapter 4. The hippocampus is also involved in retrieval of recently learned information. The medial temporal lobe initially stores an event prior to its consolidation in distributed areas throughout the neocortex (McClelland et al., 1995). Finally, certain areas of the prefrontal cortex in both the left and right hemispheres are more active when retrieval succeeds than when it fails (Buckner, 1996). Thus, a variety of prefrontal regions are involved both in the effort to search for an event representation and in its actual retrieval.

Behavioral studies also support the idea that intentional efforts to retrieve are different from the processes of successful retrieval. As pointed out earlier in this chapter, encoding processes do not function well at all when attention is not allocated to them. A comparison of the effects of divided attention on encoding and retrieval has revealed a sharp difference (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996). Dividing attention at encoding greatly reduces recall and recognition performance. The time needed to respond on a secondary task provided a measure of the effort devoted to encoding. The data showed that the effort given to encoding was under conscious control and was lessened in the divided-attention condition.

By contrast, dividing attention at retrieval had little, if any, impact on success in recalling and recognizing events. But it caused a major increase in the effort devoted to retrieval, particularly in free recall when the retrieval was most intentional and least automatic. Of great interest, the effort measure did not vary at all with the number of items successfully retrieved. Thus, the effort measure apparently reflected retrieval mode, which is under intentional control as one tries to recollect past events. Success in retrieval, on the other hand, appears automatic and undisturbed by divisions of attention. As Craik et al. (1996) pointed out, their data fit well with the neuroimaging results that discriminate the retrieval mode as a control process carried out in the right prefrontal cortex from the process that actually recovers items from memory.

Retrieval mode refers to the effort to retrieve an event from long-term memory as opposed to its actual retrieval. Activation in the right prefrontal cortex supports retrieval mode, whereas numerous regions are involved in successful retrieval.

Encoding Specificity

Tulving (1983) proposed that remembering depends on activating precisely the same cues at retrieval that were originally encoded with the event in question. Tulving's principle of **encoding specificity** asserts that "specific encoding operations performed on what is perceived determines what retrieval cues are effective in producing access to what is stored" (Tulving & Thomson, 1973, p. 369). The interaction between encoding and retrieval conditions is the key to high levels of recall and recognition.

For instance, Light and Carter-Sobell (1970) presented people with a cue and a target word to study, such as STRAWBERRY-JAM. Later, the participants tried to recognize whether the target word (JAM) had appeared during study. If on the test the cue word was switched (TRAFFIC-JAM), they had a harder time recognizing the target than if the retrieval cue matched the encoding cue. Furthermore, when encodings are highly distinctive and retrieval cues are available that match the encoding cues precisely, recall performance can be dazzlingly accurate. Mantyla (1986) obtained better than 90% accuracy in cued recall for a list of 600 words!

Recall of Unrecognizable Events. If one studies a list of words and later tries to remember them on a recognition test versus a recall test, performance is often better on the recognition test (Kintsch, 1970). A cued recall test generally yields better performance than a free recall test in which no retrieval cues are provided. But cued recall still fails to come close to the accuracy typically observed on a recognition test. This makes sense if you think of the word on the recognition test as the perfect retrieval cue; it is an exact copy. Not only is the word familiar, but it allows one to retrieve the context in which the word was originally seen in the experiment (Mandler, 1980).

Suppose that you see someone at a party who looks familiar. Recognition requires not only a judgment about familiarity but also an identification of the context in which you have encountered the person before ("Oh, yes, she was at the grocery store."). This identification is much easier when looking at the person than when given a weakly related cue ("think of shopping") or given no cues at all.

Tulving and Thomson (1973) arranged a situation in which the encoding-specificity principle counterintuitively predicts accurate recall of an unrecognizable word. They presented a list of to-be-remembered target words (e.g., BLACK) along with encoding cues that were weak associates of the targets (e.g., TRAIN). After presentation of the list, the participants were given strong semantic associates of the target words (e.g., WHITE) and were asked to think of related words. Not surprisingly, target items (BLACK) were often generated. Next, the participants were asked to examine all of the words they generated and to indicate which, if any, had originally been presented as targets. Finally, a cued recall test was given in which the encoding context (TRAIN) served as the retrieval cue.

Tulving and Thomson (1973) found that the participants successfully recognized the targets only a quarter of the time. But when given the proper cue (TRAIN), the participants recalled the targets a stunning two-thirds of the time. What is so striking about this is that the retrieval cue is only a weak associate of the target. Yet, because it had been encoded with the word initially, it was the ideal cue for recall. This phenomenon of recall of unrecognizable words strongly supports the principle of encoding specificity.

Tip of the Tongue States. Surely, you have seen a familiar face that you could not quite place, or perhaps you could not retrieve the person's name. People often experience a feeling of knowing or familiarity in which some name, word, date, or other information cannot be retrieved despite a certainty that it is available in memory (see Box 5.2). When such feelings become particularly intense, psychologists refer to the experience as a **tip of the tongue (TOT) state.** Brown and McNeill (1966) studied such TOT states for words by giving people definitions of rare words and asking them to recall the words. Of interest, when people experienced a TOT state, they could correctly identify the number of syllables in the forgotten word more than 60% of the time. Further investigation showed that "TOTs (a) are a nearly universal experience, (b) occur about once a week, (c) increase with age, (d) are frequently elicited by proper names, (e) often enable access to the target word's first letter, (f) are often accompanied by words related to the target, and (g) are resolved during the experience about half of the time" (Brown, 1991, p. 204).

Box 5.2 A Demonstration of the Tip of the Tongue State

Try to name the capitals of the following states in the United States and countries in the European Union. Is there one (or more) for which you believe you know the answer but cannot retrieve it? Can you guess how many syllables are in the name? Can you guess the initial letter of the name?

State	*Country*
Maine	Finland
New Hampshire	Belgium
Georgia	Denmark
South Dakota	Italy
Arizona	Germany
Tennessee	United Kingdom
Rhode Island	Luxembourg
Iowa	Portugal
Virginia	Austria
Oregon	Sweden

TOT states suggest that information may be available in memory but inaccessible. The forgetting seems to be clearly caused by a failure to find the right retrieval cue. Sometimes, we can successfully recall the forgotten information by stumbling on a thought or perception that triggers the memory. The principle of encoding specificity explains this as another example of cue-dependent forgetting. Numerous other experiments have documented the principle that the specific cues associated with an event during learning provide the key to later recall (e.g., Begg & White, 1985; Jacoby, 1974).

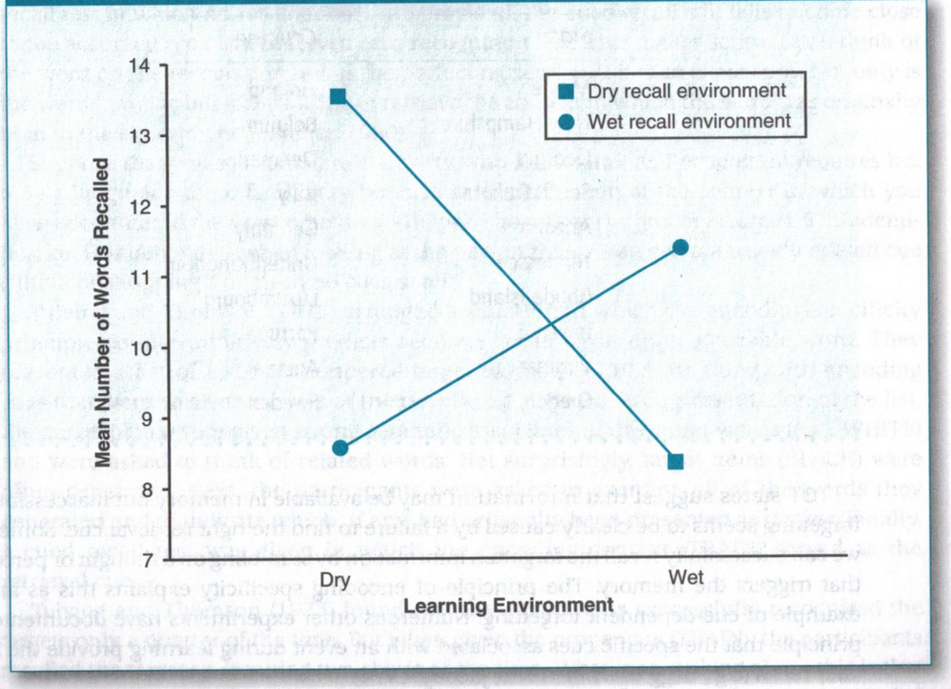
Environmental Context. The context in which learning is experienced ought to serve as a retrieval cue at the time of test, according to the encoding specificity principle. This has

been tested by varying the environmental and psychological context in a large number of experiments. Of interest to students, Smith, Glenberg, and Bjork (1978) had people learn a list of words in a particular room and then later try to recall them in the same room or in one very different in appearance. The environmental context affected recall in the direction one would expect. The same room provided the right retrieval cues and supported superior performance. Although the effect was not large, it might pay off to study for an exam in the same room in which you will be tested.

A more compelling demonstration of the importance of reinstating the encoding context was provided by Godden and Baddeley (1975). Scuba divers learned a list of words underwater or on dry land. They were then tested in one of these two contexts, and the results showed a strong crossover interaction, as shown in Figure 5.4. Recall dropped substantially when learning occurred on dry land but then testing was underwater. However, when learning was underwater, performance improved by going underwater again at test relative to testing on land.

Psychological Context. The emotional state of the individual also may serve as an effective retrieval cue. A **mood congruence effect** may be studied by instructing people to think

Figure 5.4 Number of words recalled in a dry or wet environment after learning in a dry or wet environment.



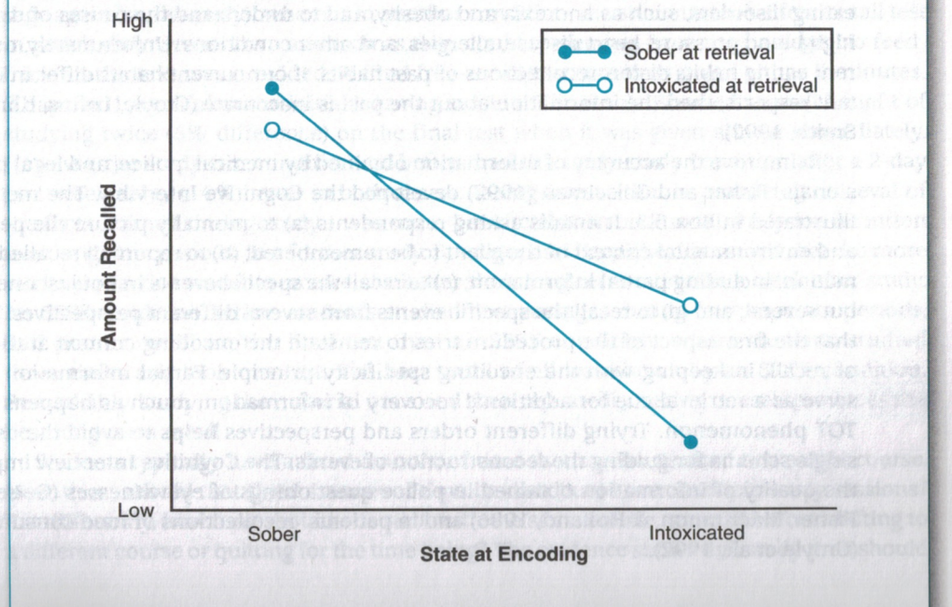
SOURCE: From Godden, D. R., & Baddeley, A. D., Context-dependent memory in two natural environments: On land and underwater. *British Journal of Psychology, 66,* 325–331. Copyright © 1975.

about positive or negative life events in order to induce a happy mood or an unhappy mood. Bower (1981) found that the best learning occurs when the material being learned fits with the induced mood. Thus, depressing information is best learned when in a sad mood (Blaney, 1986).

State-dependent learning is sometimes observed when a person's mood or state of consciousness (e.g., sober, intoxicated) is directly manipulated during learning and retrieval. Under such conditions, recall performance when one's mood at retrieval matches the mood at the time of learning is not reliably better than when the moods do not match. Several drugs, on the other hand, have shown state dependency effects when dosages are sufficiently large to produce clear signs of intoxication, such as slurred speech (Eich, 1980, 1989; Overton, 1971). These include commonly used drugs such as alcohol, barbiturates, and marijuana. Information learned in a sober state is better retained when later recalled in a sober state, whereas information learned in an intoxicated state is better retained when tested while intoxicated. As one would expect from what we know about the importance of cognitive effort and elaboration during study, recall is by far the best during sober learning and sober testing.

However, there is a strong asymmetry in the relationship (Eich, 1989). Alcohol and prescription drugs (e.g., benzodiazepines such as Valium and Xanax) reduce the encoding and storage of details about the context of an event (Curran, 2000). As illustrated in Figure 5.5,

Figure 5.5 Asymmetry in drug-induced state-dependent learning.



if one is sober at study, then retrieving the information at the time of test is relatively easy both when one is sober and when one is intoxicated. At times, intoxication at retrieval can, in fact, increase the amount remembered (Curran, 2000). By sharp contrast, when the learner is initially intoxicated at study, there is a consistent decline in performance when the retrieval mode is shifted to sobriety.

It should also be noted that intoxication during encoding greatly impairs the degree of learning in the first place. An alert and sober state of mind is required for successful learning (Curran, 2000). It has been known for centuries that drugs can cause forgetting. Alcohol is by far the most widely used drug with this feature, but millions of people also take antidepressants and antianxiety drugs that can cause some memory problems. The elderly are particularly vulnerable because they may combine medications that have psychoactive properties. For example, 10% to 15% of the population over 65 years of age take sleeping pills that can produce brief memory loss. In extreme cases, older adults can experience confusion and memory loss that resembles dementia. It is important for physicians to distinguish between true organic dementia and dementia that is temporarily induced by prescription medications.

Tip of the tongue experiences and state-dependent learning show that the right retrieval cues are critical to successful recall, as predicted by the encoding specificity principle.

Application. The encoding-specificity principle has important implications for medical, police, and legal professionals who rely on the recollections of an individual to determine the facts of a case. For example, doctors often try to obtain an accurate clinical picture by interviewing a patient about, say, eating habits. An accurate picture is needed to diagnose eating disorders, such as anorexia and obesity, and to understand the causes of diabetes, high blood pressure, heart disease, allergies, and other conditions. Unfortunately, our current eating habits distort recollections of past habits. If our current habits differ in important respects, then the information about the past is inaccurate (Croyle, Loftus, Klinger, & Smith, 1992).

To improve the accuracy of information obtained by medical, police, and legal professionals, Fisher and Geiselman (1992) developed the Cognitive Interview. The method is illustrated in Box 5.3. It entails asking respondents (a) to mentally picture the personal and environmental context of the event to be remembered; (b) to report all recalled information, including partial information; (c) to recall the specific events in not just one order but several; and (d) to recall the specific events from several different perspectives. Notice that the first aspect of the procedure tries to reinstate the encoding context at the time of recall, in keeping with the encoding specificity principle. Partial information might serve as a retrieval cue for additional recovery of information, much as happens in the TOT phenomenon. Trying different orders and perspectives helps to avoid the use of a single schema for guiding the reconstruction of events. The Cognitive Interview improves the quality of information obtained in police questionings of eyewitnesses (Geiselman, Fisher, MacKinnon, & Holland, 1986) and in patients' recollections of food consumption (Croyle et al., 1992).

Box 5.3 Encoding and Retrieval Procedures Used in the Cognitive Interview Method

Try to form a mental image of all the circumstances surrounding the event.

Report everything you can remember about the event. Report even bits and pieces of information that are incomplete.

Recall the event in several sequences rather than just one.

Recall the event from several perspectives rather than just one.

STUDY STRATEGIES

College students are expected to learn the often novel concepts and factual information of the disciplines that they study. Such semantic knowledge is typically presented in lectures and in textbook assignments. Recent research has investigated the relative effectiveness of study strategies in learning such educational materials. This line of work will be discussed next now that the broad field of research on encoding of episodic information into long-term memory has been covered.

Roediger and Karpicke (2006) had college students read text passages on general scientific topics during a learning session. In one condition, the students restudied the passage again (study-study), whereas in another condition, the students took a free-recall test in which they wrote down as much as they could remember from the passage. No feedback on the text was provided. A final free-recall test was then given either 5 minutes, 2 days, or 1 week after the initial learning session. The results showed a small benefit of studying twice (6% difference) on the final test when it was given almost immediately. However, the study-test condition did better than the study-study condition after a 2-day or 1-week delay (14% better in both cases). Taking a test—that is, practicing retrieval of the facts learned during study—was more beneficial than additional study for retention over long time periods. In a further study, Roediger and Karpicke discovered that the more retrieval practice students receive, the better their long-term retention a week after study. An SSSS condition, where students studied text passages during four separate periods, had poorer recall on the final test than an SSST condition, where students studied three times and took one test. The best recall of all was shown by an STTT condition. Remarkably, studying the material once and then repeatedly testing oneself produces the best long-term recall.

Students typically have a fixed amount of time that can be devoted to a single course. How, then, should that fixed amount of time be distributed over multiple study sessions? Put differently, how long should one stick with the same course material before shifting to a different course or quitting for the time being? The evidence shows that study time should

continue only as long as is needed for the material to be mastered, but that then one should quit or shift to different material (Rohrer and Pashler, 2007). Overlearning is helpful only for retention over a matter of days (up to a week or so), but for longer retention intervals, it is an inefficient use of time.

The spacing effect refers to the superior performance obtained when study time is spaced or distributed over time rather than massed or crammed. In general, a given amount of study time is most effective when it is divided into units and distributed over days or weeks of study. Saving it all up for a long cram session the night before the exam is not a good strategy. Determining the ideal amount of spacing between study sessions is complicated by Rohrer and Pashler's (2007) findings that for very long retention intervals (6 months), the optimal spacing is also lengthy (1 month between study sessions), but for shorter retention intervals (10 days), the optimal spacing is correspondingly shorter (1 day between study sessions).

Note taking is a widely used strategy when learning from lectures or reading assignments. Although reviewing notes is a useful method of studying, it does not capitalize on the fact that retrieval practice through self-test is highly effective. The Read, Recite, and Review or 3R strategy explicitly introduces retrieval of information learned first by reading a text and then reciting out loud all that can be remembered. Then, as a means of self-assessment and as an opportunity for further study, the student reviews the reading passage again. McDaniel, Howard, and Einstein (2009) found that the 3R strategy improved free recall of the facts given in a text passage compared with either re-reading the passage or taking notes on it. The advantage of 3R was obtained on both an immediate test and on one administered a week after studying the material. Thus, before re-reading an assignment, students should attempt to recite it first.

Throughout the present chapter, a variety of learning principles relevant to educational settings have been identified. The work reviewed in this final section on storing facts and concepts from reading assignments indicates three clear best practices for effective studying: (1) Self-test often to practice retrieval, (2) space one's study time rather than massing it, and (3) supplement note taking with the 3R strategy. Notice that the 3R strategy can be used for studying notes taken from a lecture as well as for reading assignments. Moreover, one can try to recite material read or heard earlier at any time during the day, not just during times set aside for studying. McDaniel et al. (2009) recommended that students practice retrieving course information while walking to class or exercising, for example. The key point is that self-testing is an integral part of the study process.

SUMMARY

1. Long-term memory is not a unitary store, according to the multiple-systems hypothesis regarding the structure of long-term memory. There is a fundamental division in long-term memory between declarative (knowledge of what) and nondeclarative (knowledge of how) systems. Declarative memory is further divided into episodic memory (events that are encoded in terms of specific times and places of occurrence) and semantic memory (general knowledge of facts and concepts). Nondeclarative memory includes skill learning, priming, conditioning, and habituation.

2. Encoding and storage of episodic information in long-term memory varies with the kind of rehearsal given to information stored in short-term memory. Simply recycling information through attention and short-term storage, or what is called maintenance rehearsal, is not highly effective. Repeating a list of words illustrates maintenance rehearsal. Elaborative rehearsal is superior and depends on establishing links between the information held in short-term memory and the information already stored in long-term memory, for example, by forming visual images of the objects referred to by the words in a list. Mnemonic techniques, such as the method of loci, are kinds of elaborative rehearsal.

3. The level of processing also affects learning success, with deep semantic processing supporting better memory than shallow sensory processing. This probably reflects the importance of establishing a distinctive memory representation that can be easily retrieved in the future. Finally, the organization of newly learned information is necessary for successful recognition and recall.

4. Encoding processes are important, but they cannot be considered apart from retrieval processes. The encoding specificity principle asserts that events are recognized or recalled only when retrieval cues at the time of test match the encoding cues at the time of learning. The retrieval cues allow one to activate the to-be-remembered episode and its context. From this perspective, forgetting represents a failure to access an episode because the retrieval cues are inadequate.

5. Mental time travel refers to the capacity for recollecting past events and envisioning future events using reconstructive retrieval processes. The default network of the brain is activated by traveling backward in mental time or traveling forward into the imaginary future. An everyday form of future thinking occurs in tasks requiring prospective memory. This refers to remembering to take some specific action at some point in the future. One must first form an intention to perform an action in a specified window of time. Two kinds of retrieval processes are involved in successfully remembering to do something later. The first is to engage in the attention-demanding retrieval mode of monitoring the environment for cues to act as planned. The second is to rely on spontaneous, relatively effortless retrieval triggered automatically by environmental cues, as when the thought to act just pops into mind.

KEY TERMS

declarative memory
episodic memory
semantic memory
nondeclarative memory

maintenance rehearsal
elaborative rehearsal
levels or depths of processing
self-reference effect
transfer-appropriate processing
distinctiveness
flashbulb memory
relational processing
subjective organization
retrieval mode
encoding specificity
tip of the tongue (TOT) state
mood congruence effect
state-dependent learning
mental time travel
prospective memory

CHAPTER 6

Memory Distortions

Each day, one has countless thoughts, fantasies, and recollections about the events of earlier in the day, last week, or years ago. When we fantasize about events that may happen in the future, there is no confusion about whether the mental experience accurately reflects reality. However, when we think back on events from the past, the possibility of confusing our memory of events with the actual events that transpired is quite real. Where is the line that separates fantasies about the past from accurate recollections? How does one know that an event is not distorted in minor or even major ways? Memory distortion can be more pernicious than forgetting because the rememberer may not be able to tell that the recollection is in error.

As will be seen in this chapter, there are several ways in which encoding, storage, and retrieval processes can lead to inaccurate, distorted episodic memory. This chapter also documents the role of organized sets of concepts or schemas in constructing episodic representations at encoding and in reconstructing them at retrieval. An episodic memory is influenced by the general knowledge of the world stored in semantic memory. The rich warehouse of semantic memory is necessary for the abstract thinking capacities of humans, but it can get in the way of perfectly accurate memories of past events.

RECONSTRUCTIVE RETRIEVAL

Schemas play a critical role in perception by providing expectations, as discussed in Chapter 2. They play a similar crucial role in memory. The schemas of long-term memory represent everything that we know. These schemas are intricately organized in a complex web of relations. The concepts and facts of semantic memory and the specific autobiographical events of episodic memory are linked in countless ways.

Imagine a scenario of a cat prowling for mice. Where might the cat find mice? In a barn on a farm, of course. Immediately, images of farms come to mind. You might recall the farm you grew up on, one you visited as a child, or one you saw in a movie last week. In turn, images of cows, pigs, horses, and other farm animals might then come to mind. The thought of a horse would perhaps bring to mind the time you went horseback riding with