example, if people practice organizing single items into larger groups or chunks, they can increase their memory span dramatically. Organizing items into chunks is a process of reduction coding, which functionally reduces the number of items to be remembered. Immediate memory can also be facilitated by elaboration coding, which involves adding well-remembered information to the information to be remembered. Both kinds of coding illustrate that encoding is an active process that entails transforming the presented information.

Forgetting in immediate memory results partly from the passage of time, that is, through a process of gradual weakening or decay. Forgetting also results from interference, that is, from the processing of items that are similar to the items that are to be remembered. Proactive interference occurs when previously learned items impair the retention of items presented later. Proactive interference stems from problems in retrieving information, for example, from the failure to discriminate the items that are to be remembered from previously learned items. Interference can also occur retroactively, as when the processing of items at one time impairs the retention of previously learned items. Retroactive interference stems in part from the failure to allocate sufficient resources to the task of remembering. In many situations, decay and interference probably interact. For example, as items decay over time, they may become less distinctive and more difficult to discriminate from the items that had been learned previously, thereby facilitating the occurrence of proactive interference.

Most studies of retrieval from immediate memory have used a high-speed recognition procedure in which a test item is presented and the subject indicates quickly whether the test item matches one of a set of remembered items. Under some conditions, subjects perform this task by searching or scanning the remembered items serially and exhaustively. In particular, they compare the test item to each remembered item one at a time. But when the remembered items are either highly familiar or highly unfamiliar, the subjects do not execute a memory search. Rather, they evaluate the level of familiarity of the test items. So retrieval, like many aspects of cognition, is a highly flexible process.

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Chapter 4 Encoding and Remembering

Immediate memory is important in many situations, yet it is too temporary to satisfy all of the demands of everyday life. Nowhere is this more evident than in the case of a man known in the clinical literature as H.M. (Milner, 1966; Milner, Corkin, and Teuber, 1968).

H.M. was a motor winder in his late twenties who suffered severe epileptic seizures that interfered with his work and presented a major health hazard. To reduce the seizure activity, H.M. allowed surgeons to remove the internal part of the temporal lobes of his brain, which contains the hippocampus, the amygdala, and other structures that are known to play a role in remembering.

The surgery controlled his epilepsy and did not impair his intelligence. But the operation did impair H.M.'s memory. He remembered events from early in life but did not remember the events from one or two years just before the operation. The larger problem, however, was that H.M. had difficulty learning and remembering information about the events that followed the operation. In most instances, he remembered new information for only seconds or a few minutes. He and his family moved following the operation, but even after a year H.M. had not learned the new address. When he had to find his own way home, he often returned to the house in which he had lived prior to the operation. He read and reread the same magazines, showing no signs of boredom. And he told the same jokes repeatedly without recognizing that he had told them before. He even had to be reminded each day to shave. Overall, H.M. lived as a creature trapped in the immediate present, unable to remember for long.

The case of H.M. is admittedly extreme. Yet it demonstrates the importance of long-term memory. Without the capacity for forming new long-term memories, we would be unable to learn and to benefit from our previous experiences.

This chapter concerns the processes involved in remembering new information over relatively long periods of time. We begin by analyzing the multistore model of memory, which stated that the memory system contains separate short-term and long-term stores. According to the model, incoming information is retained in the short-term store, a temporary storage system. By rehearsing or by encoding the information, the information is transferred to the long-term store and can be retained over long periods of time. The multistore model guided research concerning remembering for almost 20 years. The model is no longer accepted widely, but it still merits our attention. By understanding the model and its limitations, we gain insight into current research and theory, much of which arose as either an extension of or a reaction against the multistore model.

In the second section of this chapter, we inquire into current conceptions of remembering, which stress the importance of encoding processes. Craik and Lockhart (1972) argued persuasively that remembering was best seen as the product of encoding processes rather than of retention in several memory stores. They proposed that people can analyze incoming information on numerous levels. On the simplest level of analysis or, as they called it, level of processing, the person analyzes the physical properties of the stimulus. For example, if the stimulus were a printed word, one might notice whether the word was capitalized or uncapitalized, long or short. On a deeper level of processing, the semantic level, one might determine the meaning of the word. Craik and Lockhart suggested that memory depended upon the level of processing: the more deeply the information had been processed, the longer it would be remembered. This conception, which is called the *levels of processing model*, abandoned the idea that there are separate short-term and long-term stores. We shall examine this model in detail because it reshaped the direction of research and because its offshoots are highly influential at present.

The levels of processing model initially assumed that processing occurs in a fixed sequence of stages. When this assumption ran aground, theorists modified the model by emphasizing the effects of the elaborateness, not the depth, of processing. An item can be processed elaborately by relating it to other items, for example, by joining various words in a sentence. Or the item can be analyzed further in isolation, for example, by noting that the word *bat* has several meanings rather than a single meaning. According to the revised model, the more elaborately an item is processed, the better it will be remembered. Using this idea as our conceptual framework, we shall examine the effects of organization and of mnemonic systems upon retention.

One of the central themes of the chapter is that people can encode information in a variety of ways, and they often tailor their coding strategies to satisfy the demands of the task at hand. For example, in studying for a multiple choice test designed to evaluate your memory for specific facts, you would probably memorize many specific facts, perhaps by using the strategy of rehearsing the facts repeatedly. You would no doubt study differently for an essay test that required you to evaluate and to integrate concepts rather than to memorize passively. As this example indicates, people have extensive knowledge of how to encode in order to remember different kinds of information. In other words, they know how to remember. This knowledge is called metamnemonic (pronounced meta-ni-mön-ic) knowledge, though we shall often use the simpler term *metamemory* (Flavell and Wellman, 1977). In the last section of this chapter, we explore the metamnemonic knowledge that people use in selecting and in evaluating their strategies for remembering.

THE MULTISTORE MODEL

Extending the theoretical work done by Broadbent (1958) and by Waugh and Norman (1965), among others, Atkinson and Shiffrin (1968) proposed one of the most detailed and influential multistore models. They viewed the processing system as a set of three *memory structures:* the sensory store, the short-term store, and the long-term store. They stated that these structures are permanent, built-in components of the system that do not vary from one situation to another.

Having discussed sensory memory, we will concentrate in this section on the short-term store and the long-term store. According to the model, the short-term store retains information temporarily, for about 15 seconds, and it has a capacity for holding about seven chunks of information. Items can be lost from the short-term store through both decay and interference. In contrast, the long-term store retains information for long periods of time, perhaps permanently, and it has an unlimited storage capacity. The information in the long-term store could decay. But forgetting resulted primarily from the failure to retrieve the stored information.

The model also included a set of control processes, which are operations that people use to manipulate the information within a memory store or to transfer information between stores. Two of the most important control processes were rehearsal and coding. According to the model, rehearsal both maintains items in the short-term store and transfers items to the long-term store. Presumably, the more we rehearse an item, the more likely it is that we will remember that item over long periods of time. The second control process, coding, involves transforming the information in the short-term store in ways that facilitate storage in long-term memory. For example, a four-digit number retained in the short-term store might be transformed into a running time, as in the case of S.F. discussed earlier.

Control processes, unlike the memory structures, can be used in flexible ways. For example, a person might choose to rehearse some items rather than others, and the person could even choose not to rehearse at all. Further, some people might prefer to learn information by engaging in rehearsal, whereas other people might prefer to form images or to organize information. The control processes, then, add flexibility to the processing system.

The model of Atkinson and Shiffrin illustrates the multistore model, but our chief concern is with the features that are common to various models. In general, multistore models have two important features in common. First, they posit the existence of separate short-term and long-term stores. Second, they hold that rehearsal maintains information in the short-term store and transfers information to the long-term store. In this section, we examine the cases for and against both assumptions. When we speak of the multistore model, we refer to a generic model that makes these two assumptions.

Evidence in Favor of the Model

Some of the evidence that suggests that there are separate short-term and long-term stores comes from studies of people who have suffered brain damage. Drachman and Arbit (1966) evaluated the span of immediate memory of people who, like H.M., had sustained injuries to the temporal lobes of the brain. They presented sequences of digits that varied in length, and they repeated each sequence until the patient had recalled it correctly. They observed that the patients' span of immediate memory was about the same as that of individuals who had not sustained brain damage. But the patients took many more trials than the undamaged people to learn sequences of digits that exceeded their memory span. Thus the patients showed a deficit in learning new information, yet their capacity for immediate memory was normal. Further, they showed normal intelligence and remembered events that had occurred prior to the brain injury. In terms of the multistore model, the brain damage had

left the memory stores of the patients intact but had impaired the ability to transfer information from the short-term store to the long-term store. This interpretation applies also to the case of H.M., described at the beginning of this chapter.

Studies of people who suffer from Korsakoff's syndrome have produced similar observations. *Korsakoff's syndrome* is produced by chronic alcoholism, which, over a period of years, leads to vitamin deficiencies and eventually to brain damage. In many cases, hospitalization and treatment follow an acute drinking phase or binge that renders the alcoholic confused and amnesic. The patients show severe retrograde amnesia in that they forget the events that had occurred several months prior to the last drinking binge. The patients also show marked anterograde amnesia, the failure to remember events that had occurred after the last binge. Patients suffering from Korsakoff's syndrome show a normal span of immediate memory but show an impaired ability to remember lists of words over long periods of time (Zangwill, 1946).

Overall, these observations suggest that people have separate short-term and long-term stores and that damage to the brain, particularly to the temporal lobes, impairs the ability to transfer information from one store to the other. Although these observations support the multistore model, it is desirable to obtain converging evidence of separate memory stores from studies of undamaged individuals. In fact converging evidence has been adduced from studies of memory capacity, coding, and free recall.

CAPACITY DIFFERENCES

In the preceding chapter, we saw that the span of immediate memory is usually limited to about seven chunks. On the other hand, no one has discovered limits on our capacity for remembering over long periods of time. In our lifetimes, we learn a tremendous number of words, places, faces, and events. These observations have suggested to many theorists that we have two memory stores that differ in their storage capacity. Presumably, the span of immediate memory is limited because the short-term store can retain only about seven chunks. After the short-term store has been filled up, new items cannot be stored, so they will not be remembered. If a new item were allowed to enter the short-term store, that item would displace one of the previously stored items, which would then be forgotten. Unlike the short-term store, the long-term store has unlimited capacity and can retain an indefinitely large amount of information.

PHONEMIC VERSUS SEMANTIC CODING

Evidence from studies of coding has also been used to argue that separate short-term and long-term stores exist. For example, Conrad (1964) observed that people remember items over a short period of time by encoding the items verbally. He presented sequences of six letters such as *B* and *S* aurally against a background of nonverbal noise at a rate of one letter every three-quarters of a second. The subjects' task was to write down the letters they had heard. The results were that the subjects often erred by recalling items that sounded like the presented items. For example, when *B* had been presented, the subjects often erred by recalling *C* or *V*, which sound like *B*. But they seldom erred by recalling the letter *F*, which looks like *B* but does not sound like *B*. Overall, the greater the phonemic similarity (similarity in sound) between two letters, the more often those two letters were confused by the subjects. Because the subjects confused letters that sounded alike but not those that looked alike, Conrad concluded that the subjects had encoded the letters verbally. Conrad obtained highly similar results when he repeated the experiment but presented the letter sequences visually. Regardless of whether the letters had been presented visually or aurally, then, the subjects encoded the items verbally. This outcome suggested that the short-term store retained information only in a verbal format. Because the code contained information concerning the sounds of the items, the code may be called a phonemic code.

In contrast, the long-term store seemed to retain semantically coded information. For example, Sachs (1967) read her subjects stories, one of which concerned Galileo. One of the sentences in the middle of the story was *He sent a letter about it to Galileo, the great Italian scientist.* Without advance warning, Sachs stopped reading the story either 0, 80, or 160 syllables following the reading of the sentence. She then presented one of four test sentences:

Identical: He sent a letter about it to Galileo, the great Italian scientist.
Semantic change: Galileo, the great Italian scientist, sent him a letter about it.
Syntactic change: A letter about it was sent to Galileo, the great Italian scientist.
Formal change: He sent Galileo, the great Italian scientist, a letter about it.

The subjects' task was to indicate whether the test sentence had occurred verbatim in the story. Only the first test sentence had actually occurred in the story. The other test sentences differed from the original with regard to either meaning or grammatical structure.

When the memory test occurred immediately after the reading of the sentence in the story, the subjects responded accurately to all four kinds of test sentences. So they must have remembered the exact wording of the sentence for at least a short time. But when 160 syllables had intervened between the reading of the sentence and the memory test, the subjects responded accurately only to the test sentence labelled "semantic change." Thus they remembered the meaning of the sentence but not its exact wording or grammatical form. This observation suggested that the information in the long-term store had been encoded semantically. Overall, then, it appeared that the short-term store retained phonemic information, whereas the long-term store retained semantic information.

SERIAL POSITION EFFECTS

One of the most commonly used procedures for studying memory is the ***free recall*** procedure. In a typical free recall task, the experimenter presents a list of, for example, 15 words at a rate of one word every 3 seconds. The subjects' task is to recall the items in any order. The results of this type of procedure, shown by the gray solid line in Figure 4.1, were that the level of recall was highest for the words that had been presented at the beginning and end of the list (Glanzer and Cunitz, 1966). This outcome is called the ***serial position effect*** because the retention of an item depended upon the position in which it had been presented. The serial position effect is so large and easy to replicate that it has attracted extensive attention since Ebbinghaus' time. In general, the effect consists of two components. The high level of retention for the first few items is called the ***primacy effect;*** the high level of retention for the last few items is called the ***recency effect.***

Many investigators believe that the primacy effect reflects the output of the long-term store, whereas the recency effect reflects the output of the short-term store. One of the chief reasons is that some variables in-

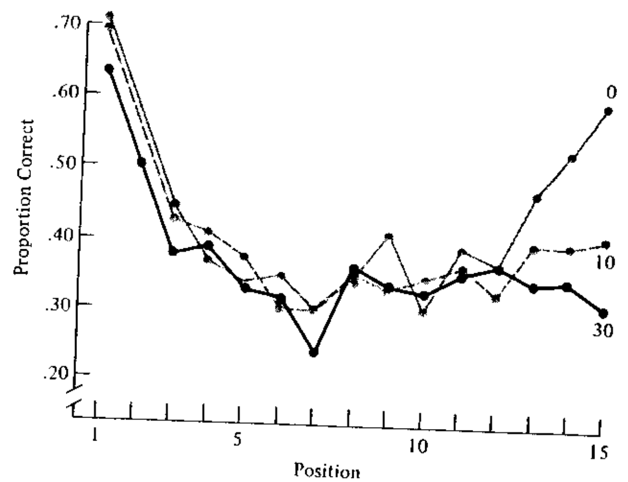

Figure 4.1 The serial position effect in free recall. Interposing a delay of 10 or 30 seconds between the presentation of the list and the test of retention reduced the recency effect but did not influence the primacy effect. (From Glanzer and Cunitz, 1966.)

fluence the recency effect but not the primacy effect. For example, Glanzer and Cunitz (1966) presented a list of 15 words followed by a retention interval of 0, 10, or 30 seconds. During the 10- and 30-second retention intervals, the subjects performed a counting task that was intended to prevent rehearsal. As Figure 4.1 shows, the size of the recency effect depended on the duration of the retention interval. Indeed, the 30-second retention interval eliminated the recency effect. Presumably, the last few items had been retained briefly in the short-term store but had been forgotten because of decay or interference during the retention interval. But when retention was tested immediately, the subjects could recall the last few items at the beginning of the test, before the items had been lost from the short-term store. In fact, the subjects did tend to recall the last few items first and then recall the initial items from the list. Figure 4.1 also shows that the length of the retention interval did not influence the primacy effect. According to the multistore model, the first few items were in the long-term store, so retention of those items was not influenced by the length of the retention interval.

Whereas some factors influence the recency effect but not the primacy effect, other factors do the reverse. For example, Glanzer and Cunitz (1966) presented a 20-item list to three different groups of subjects at a rate of 3, 6, or 9 seconds per word. They then asked the subjects to recall the list immediately. The results were that the rate of presentation did not influence the size of the recency effect, but it did influence the size of the primacy effect. In particular, the slower the rate of presentation had been, the higher the level of recall was for the first five or so items in the list. Glanzer et al. suggested that the slower the rate of presentation, the more the subjects rehearsed the initial items in the list. The extra rehearsal facilitated retention by transferring the items to the long-term store. This account is consonant with the idea that the primacy effect reflects the output of the long-term store.

This interpretation of the primacy effect draws additional support from experiments in which rehearsal was measured directly. Rundus and Atkinson (1970) presented 11 lists of 20 unrelated nouns at a rate of one word every 5 seconds. The subjects were asked to rehearse aloud the word that was being shown and any of the other words from the list. Following the presentation of each list, a test of free recall was administered. As shown by the solid line in Figure 4.2, the usual serial position effect occurred: there were large primacy and recency effects. Figure 4.2 also shows how many times the words at each position in the lists were rehearsed. For all but the last three items in the list, there was a marked correspondence between the number of rehearsals and the level of retention. Thus the primacy effect seems to depend upon the amount of rehearsal, suggesting that the effect is a long-term storage phenomenon. This observation supports the view that rehearsal leads to the transfer of

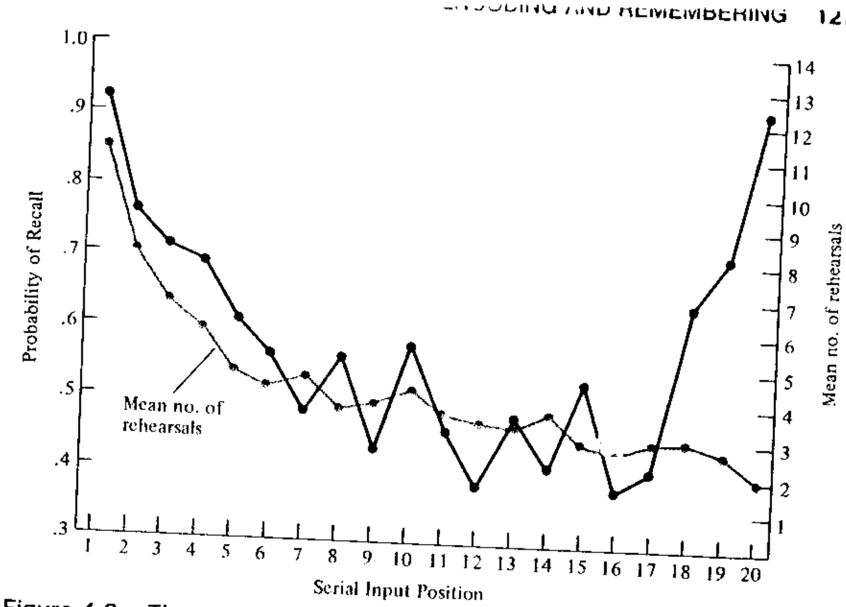

Figure 4.2 The role of rehearsal in the serial position effect. The black line shows the level of recall of the items at various input positions. The gray line indicates how many times each item had been rehearsed. (From Rundus and Atkinson, 1970.)

information from the short-term store to the long-term store. The results also show that the recency effect does not depend on the amount of rehearsal, presumably because the last few items were retained in the short-term store without extensive rehearsal.

Overall, the multistore model provides a coherent account of the serial position effect. The subjects rehearse the initial items frequently, thereby transferring the items to the long-term store. This long-term storage accounts for the primacy effect. The subjects retain the last few items in the short-term store and recall those items first in the retention test, before the items have been lost from the short-term store. This accounts for the recency effect. The items in the middle of the list are recalled poorly for at least two reasons. First, they are so far from the end of the list that they are not in the short-term store at the beginning of the retention test. Second, the subjects did not rehearse them extensively because only a few items can be rehearsed at a time. If the subjects had rehearsed all of the items equally, they might have failed to rehearse any of the items enough times to allow for long-term storage. By rehearsing the initial items extensively, the subjects managed to transfer at least a few items to the long-term store.

As you can see, the multistore model accounted for a wide range of observations. The model was attractive partly because of its simplicity and its clarity. It defined the processing system in terms of three concrete memory stores, each of which stored and processed information in a unique, well-specified manner. Additionally, the model specified clearly how information was transferred throughout the system. For a time, some theorists believed that they could achieve a relatively complete account of cognition by simply working out the details of the model. Further research, however, shattered this optimistic outlook.

The Case Against the Model

One major problem that the model faces concerns the manner in which information is encoded. Initially, the multistore model held that the short-term store retained only phonemic information. But numerous experiments established that visual coding also occurs in immediate memory tasks. In one experiment (Kroll, Parks, Parkinson, Bieber, and Johnson, 1970), subjects shadowed a series of letters read in a male voice. As they shadowed, a test letter was presented. In the auditory condition, the test letter was read in a female voice. In the visual condition, the test letter was flashed briefly on a screen. The subjects' task was to shadow without errors but also to remember the test letter during a retention interval that lasted 1, 10, or 25 seconds. The rationale was that if the subjects had encoded the test letter phonemically then the shadowed letters, which had to be encoded verbally, would retroactively interfere with the test letter. The results were that the subjects in both conditions recalled around 96 percent of the items following the 1-second intervals. But following the 25-second intervals, the level of recall was much higher in the visual condition than in the auditory condition. Thus the shadowed letters interfered with the aurally presented test letter. This suggests that the subjects in the visual condition had encoded the test letter in a visual format, thereby reducing the interference from the phonemic input from the shadowing task.

Other experiments showed that semantic information can also be retained in the short-term store (Shulman, 1972). Apparently, then, people are flexible encoders. Under some conditions, perhaps when verbal rehearsal will facilitate the performance of a task, people encode the incoming information phonemically. But under other conditions, they can encode information visually or semantically. In their initial form, multistore models were too rigid to accommodate this flexibility.

Of course, multistore models could be liberalized so as to allow for the retention of visual, phonemic, and semantic information by both the short-term store and the long-term store. But this modification adds complexity to the model. Additionally, it removes one of the clearest distinctions between the short-term store and the long-term store. Neither problem is fatal, but both problems decrease the attractiveness of the model.

LONG-TERM RECENCY EFFECTS

As discussed above, the model stated that recency effects occur because the last few items in a list are retained in the short-term store at the beginning of the recall period. On this view, the recency effect is short-lived and does not occur following retention intervals longer than about 15 seconds. Contrary to this position, Bjork and Whitten (1974) observed that recency effects can occur over longer periods of time. They presented 10 pairs of words and interposed a 12-second delay between the presentation of successive pairs. Additionally, they interposed a 20-second delay between the presentation of the last pair and a retention test in which the subjects attempted to recall all 10 pairs. During the delay periods, the subjects performed an arithmetic task designed to prevent rehearsal. Because of the length of the delay periods, the subjects should not have been able to recall any items from the short-term store. Nevertheless, a large recency effect occurred: the level of recall for the last three or four words that had been presented was very high. On the other hand, the level of recall for the words that had been presented in the middle of the list was quite low.

Many other experiments have documented the occurrence of long-term recency effects (Baddeley and Hitch, 1977; Glenberg, Bradley, Stevenson, Kraus, Tkachuk, Gretz, Fish, and Turpin, 1980). They have also tested whether the long-term recency effect reflects the output of the short-term store. If it did, then the effect should be influenced by the difficulty of the distractor task that the subjects perform during the retention interval. In performing a difficult distractor task, the subjects must use a substantial amount of the limited capacity of the short-term store. As a result, little capacity would remain for storing the last few items in a list, and the size of the recency effect would decrease. In fact, however, the difficulty of the distractor does not alter the long-term recency effect (Glenberg et al., 1980). Taken together, these observations challenge the position that recency effects indicate the existence of a separate short-term store. One could argue that the multistore model explains short-term but not long-term recency effects. But the point remains that the model fails to provide a general account of serial position effects. As the model lost its generality, it became less attractive.

CAPACITY: STORAGE OR PROCESSING LIMITS?

The multistore model attributes the limits on our cognitive capacity, for example, the limits on the span of immediate memory, to the limited storage capacity of the short-term store. Usually, theorists have assumed that the storage capacity of the short-term store was about seven items or chunks. Craik and Lockhart (1972) criticized this view, noting that experimental estimates of the number of words retained in the short-term store have ranged from two to twenty. Conceivably, the subjects in these experiments could have been remembering a constant seven chunks of information. After all, subjects can probably group several words such as *Haste makes waste* into a single unit. Unfortunately, the advocates of the multistore model never defined chunks clearly. Chunks were defined as whatever the subjects remembered seven of. Because predictions cannot be made using this type of after-the-fact account, the account is uncompelling.

Craik and Lockhart (1972) argued that our cognitive limitations reflect limitations on processing capacity, not on storage capacity. This position can account for the observations that the multistore model explained in terms of storage capacity. In the preceding chapter, for example, we saw that the limits on our processing resources can account for the limits on the span of immediate memory.

Using the concept of limited processing capacity as outlined in the preceding chapter, Craik and Lockhart were able to explain many observations concerning immediate memory. And they did so without postulating a separate short-term store. In essence, they showed that it is necessary to assume the existence of only one memory store. This position is simpler than the multistore position, which assumed the existence of separate short-term and long-term stores. Simplicity is desirable since the more complex the theory, the more difficult the theory is to use. Moreover, a theory that makes few assumptions but explains many observations is powerful and elegant, whereas a theory that makes many assumptions and explains the same body of observations is less so. In general, then, theorists want to assume the existence of as few memory stores as possible. As we shall see, the proposal of Craik and Lockhart eventually carried the day.

REHEARSAL REVISITED

The multistore model required a mechanism for transferring information from the short-term store to the long-term store. Otherwise, the model could not explain the occurrence of relatively permanent learning and retention. Initially, rehearsal was viewed as one of the primary transfer mechanisms. The effects of rehearsal appeared unequivocal, particularly in analyses of the primacy effect. This added credibility to the model. But as research continued, rehearsal proved not to be a straightforward transfer mechanism (Jacoby and Bartz, 1972).

To illustrate, consider a clever experiment by Rundus (1977), who told subjects he was studying immediate memory for numbers. In each of a series of trials, he presented two numbers that the subjects were to remember during a retention interval of 4, 8, or 12 seconds. Then he read a word which the subjects repeated aloud once per second during the re-

tention interval. He told the subjects that the word repetition task was designed to prevent rehearsal of the numbers. In fact, however, Rundus really wanted to know whether the number of times a word was rehearsed influenced the retention of that word. At the end of the experiment, the subjects were asked to recall all of the words they had rehearsed. The results were that the number of rehearsals (4, 8, or 12) had no effect on the level of recall. Thus increased rehearsal does not always facilitate long-term retention.

These observations discredited the notion that rehearsal is a straightforward process that invariably transfers information to the long-term store. No doubt the multistore model could have been modified in order to account for the complex effects of rehearsal. But that modification would have increased the complexity of the model even more. And the model was in trouble on other grounds, as discussed above. Eventually, a number of small problems added up and led theorists to reject the assumption of separate short-term and long-term stores. Today, theorists such as Shiffrin (1976), who had helped formulate the multistore model, envision short-term memory as the product of activating a portion of a single memory store.

Many laypeople think that scientists reject a model only if the model has been disproven. But this view is incomplete, if not incorrect (Kuhn, 1970). Scientists often abandon a model because it no longer seems to point toward the important questions, because it has become unwieldy and difficult to test, or because a simpler, more interesting model has evolved. All of these factors contributed to the decline of the multistore model. For example, the observations concerning rehearsal suggested that there may be different kinds of rehearsal, or different types of processing. These observations were intriguing, yet the multistore model neither explained them nor guided research into them. But Craik and Lockhart soon proposed a new conception, the levels of processing model, that accounted for the new observations and guided research into the effects of different types of processing. Their model became dominant during the 1970s, and its offshoots are still highly influential.

DEPTH, ELABORATION, AND MEMORY

The research reviewed above showed that people encode information in a flexible manner. And the weight of the evidence indicated that people tend to remember phonemically coded information for relatively short periods of time, whereas they remember semantically coded information for relatively long periods of time. The levels of processing model united these insights into a coherent framework.

Levels of Processing

The levels of processing conception was proposed initially as a framework for guiding research (Craik and Lockhart, 1972). But because it has been used by many authors as an explanatory account, we shall call it a model.

The model, like some models of attention, builds on the idea that incoming information is analyzed in stages. In the initial stages, physical or sensory features are analyzed. In the intermediate stages of processing, pattern recognition occurs, and the incoming items can be labelled. The later stages of analysis involve the abstraction of meaning. For example, having recognized and named the word *dog*, you might process that word semantically by analyzing the features that most dogs have, by thinking of associated words such as *cat*, or by forming an image of your own dog.

In this model, processing proceeds through a series of stages or levels, and a greater degree of cognitive or semantic analysis occurs at each successive stage. In other words, the stages vary with respect to the *depth of processing*, where greater depth implies a greater degree of conceptual or semantic analysis. Using this terminology, the semantic level of processing is the deepest level of processing, and the level at which naming occurs is deeper than the level at which physical features are analyzed. As Figure 4.3 shows, these levels can be thought of as lying on a continuum ranging from shallow, physical analyses to deep, semantic analyses. The greater the depth at which information is processed, the farther down on the continuum it moves.

Perception and memory have long been seen as closely related processes (Köhler, 1947). The model embodies this position, stating that

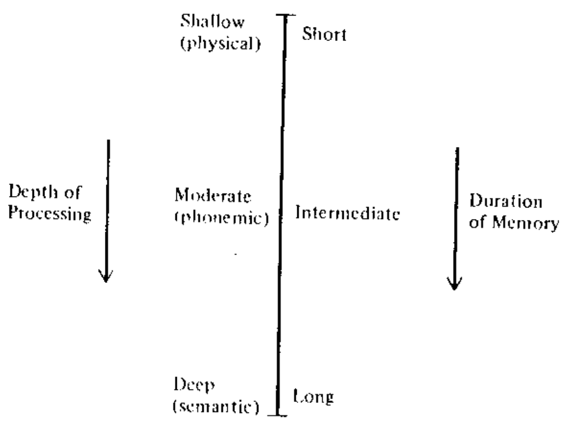

Figure 4.3 The levels of processing model. The model states that items can be processed at various depths, and the deeper the processing, the longer the items will be remembered.

memory is a by-product of perceptual analyses. As shown in Figure 4.3, the deeper the level of processing, the longer the processed information will be remembered. This thesis accounts for the retention of phonemic and semantic information in the following manner. We remember phonemic information for a moderate amount of time because that information has been processed at a moderately deep level. Similarly, we remember semantic information over long periods of time because that information has been processed at a deep level. Note that the model accounts for retention without postulating several memory stores.

Capacity limitations, according to the model, arise from constraints on our processing capacity, not on our storage capacity. The span of immediate memory is limited because only so many items can be processed at a particular time. The items that are being processed at a particular moment are said to belong to primary memory. As you can see, this view agrees with James' conception of primary memory and also with the position outlined in the preceding chapter.

TYPE I AND TYPE II PROCESSING

Because information can be maintained in immediate memory through rehearsal, Craik and Lockhart proposed that capacity can be used to recirculate information at one level of processing. This type of recirculatory processing, called ***Type I processing***, maintains information in primary memory. But since it does not process information at progressively deeper levels, it does not facilitate retention once attention has been withdrawn. For example, when you mindlessly rehearse a phone number in order to remember it long enough to dial it, you are engaging in Type I processing. In contrast, ***Type II processing***, which involves processing information at progressively greater depths, does lead to longer lasting retention. In concrete terms, Type I processing maintains items at a particular point on the continuum diagrammed in Figure 4.3, whereas Type II processing moves toward the deeper end of the continuum. Type I and Type II processing correspond roughly to the short-term storage and the long-term storage posited by the multistore model. The difference is that the levels of processing model posits only one memory store and emphasizes processing rather than storage factors.

The distinction between Type I and Type II processing accounts for the observations concerning rehearsal that had posed problems for the multistore model. Rehearsal that serves only to maintain items in primary memory, sometimes called maintenance rehearsal (Craik and Watkins, 1973), entails Type I processing. Rehearsal that aids long-term retention, sometimes called elaborative rehearsal, entails Type II processing. Thus the model holds that rehearsal per se does not influence memory. What matters is the type of processing that the subjects engage in as they rehearse. If they are thinking of new associations to a word or relating the meanings of different words as they rehearse, then rehearsal will appear to have aided memory. But if they are processing information at a particular level while rehearsing, then rehearsal will appear to have had no influence on memory.

Unlike the multistore model, the levels of processing model emphasizes the flexibility of human information processing. We can process information at various points along the continuum of depth, and we can maintain information at any point along the continuum. This conception agrees with the observation that people can encode information in various ways. Equally important, it calls attention to the importance of encoding processes and of processing operations as determinants of memory. Although the model built upon ideas that had been available for some time, it constituted a radical departure from the multistore model.

SEMANTIC VERSUS NONSEMANTIC PROCESSING

The model asserts that information processed at deep, semantic levels will be remembered better over a relatively long period of time than information processed at shallow, nonsemantic levels. The obvious way to test this assertion is to tell some subjects to process information at a shallow level and to tell others to process information at a deep level. Subsequently, a test of retention could be given. The trouble, however, is that if the subjects were told they were participating in a memory experiment and were asked to process at one particular level, they might secretly process the information in whatever ways they think will aid retention. After all, most people want to perform well and to appear intelligent.

In order to control the manner in which subjects process information, investigators use *incidental learning* procedures. Specifically, the subjects are deceived into thinking that the goal of the experiment is to examine how they perform a plausible cover task when in fact the purpose is to study memory. This type of procedure was used by Craik and Tulving (1975). They told their subjects that the experiment concerned perception and the speed of reaction. In each of 60 trials, a question was presented and then a word was flashed for 200 msec. The subject's task was to answer the question about the word as rapidly as possible. The questions were designed to induce the subjects to encode the words in particular ways. To induce the subjects to encode the physical characteristics of a word such as *table*, the experimenters asked a question such as "Is the word in capital letters?" To induce phonemic coding of a word such as *crate*, the experimenters asked a question such as "Does the word rhyme with WEIGHT?" Semantic encoding was induced by asking a question such as "Would the word fit the sentence: 'They met a ______ in the street'?" Following the series of questions and answers, the subjects were unexpectedly given a recognition test for the words. The recognition test consisted of 180 words, including the 60 original words and 120 lures or distractors. The subjects' task was to indicate which words had been presented originally.

As predicted, the level of encoding determined the level of retention, as Figure 4.4 shows. Retention was poorest for the words that had been encoded on a physical level. Retention was greatest for the words that had been encoded on a semantic level. And retention was intermediate for the words that had been encoded phonemically. This pattern of observation showing better retention for semantically processed information has occurred in many experiments with many different tasks and stimuli (Bower and Karlin, 1974; Bransford, Nitsch, and Franks, 1977; Dooling and Christiaansen, 1977; Fisher and Craik, 1977; Lockhart, Craik, and Jacoby, 1976). Collectively, these results support the levels of processing model. They also agree with observations from our daily activities. As an example, we may remember the theme of our favorite novel for many years but rapidly forget what color shirt was worn by the stranger who sat beside us on the bus yesterday. Once again, semantic encoding leads to longer retention than shallower encoding.

The model would be impoverished if it accounted only for observations from incidental learning procedures. In activities such as shopping and studying for tests, people try intentionally to remember information. Fortunately, the model does apply to intentional learning. It states that the level of retention depends upon the depth of processing regardless of whether the processing occurs incidentally or intentionally. On this assumption, the level of retention should be as high following incidental semantic processing as following intentional learning.

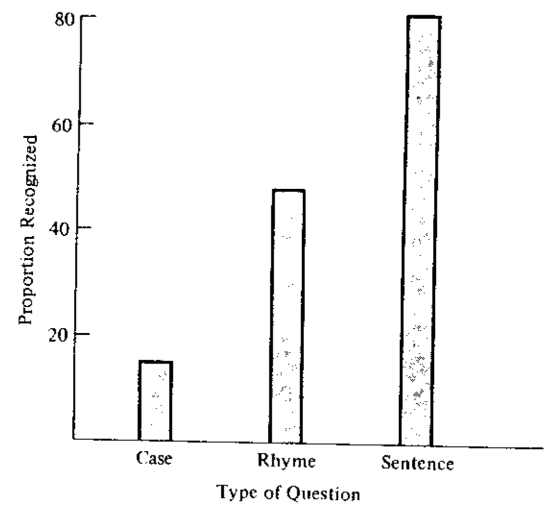

Figure 4.4 The effects of the level of encoding upon retention. (From Craik and Tulving, 1975. Copyright 1975 by the American Psychological Association. All rights reserved.)

Evidence concerning this assumption comes from an experiment by Hyde and Jenkins (1969), who read a list of 24 words to adults at a rate of 2 seconds per word. The subjects in the intentional learning condition were told they would later be asked to recall the words. The subjects in the other conditions, the incidental learning conditions, were not told they would have to remember the words. Instead, they were deceived as to the actual purpose of the experiment and were asked to perform one of several orienting tasks. In one orienting task, the subject indicated whether each of the 24 words contained the letter *E*. In another orienting task, the subjects rated each word on a scale of pleasantness and unpleasantness. These orienting tasks required subjects to process the words in very different ways. For example, rating the pleasantness of a word requires analyzing its meaning. But looking for an E does not require semantic processing. As predicted, the subjects who had rated the pleasantness of the words recalled as many words as the subjects in the intentional learning condition did. Significantly fewer words were recalled in the letter detection condition. A similar pattern of results has been obtained in many other studies (Hyde and Jenkins, 1973; Walsh and Jenkins, 1973). Collectively, these observations show that the intention to learn per se is not among the chief determinants of memory. What is most important is how the subjects encode information—how they operate upon it. Semantic processing leads to a high level of retention regardless of whether it was undertaken intentionally or incidentally.

These observations increased the credibility of the model. The model was attractive also because it was conceptually simple and because it accommodated many of the observations that had been troublesome to the multistore model. During the 1970s, the levels of processing model virtually reshaped the study of memory. Nevertheless, the model encountered problems, some of which were discovered by its chief proponents.

The Limits of Levels

The model stands largely on the observation that semantic processing leads to better retention than nonsemantic processing. But this outcome is not universal. For example, Morris, Bransford, and Franks (1977) asked subjects questions designed to induce phonemic or semantic processing, as Craik and Tulving had. Phonemic processing was induced by asking the question "______ rhymes with legal?" Semantic processing was produced by presenting statements such as "The ______ had a silver engine." A target word was read following each sentence, and subjects indicated whether the sentence rhymed or was meaningful, but they did not know they would be asked to remember the words. Two types of retention test were given. One was a standard recognition test including an equal number of target words and novel foils. The second was a rhyming recognition test that included foils and words that rhymed with the target words. The subjects' task in the rhyming recognition test was to indicate which words rhymed with the target words.

Surprisingly, opposite results occurred in the two tests. In the standard test, retention was superior for the semantically processed words. But in the rhyme test, retention was superior for the phonemically processed words. This outcome contradicts the model, yet similar observations have occurred in numerous studies (Bransford, Franks, Morris, and Stein, 1979; Stein, 1978). These observations underscore the importance of using more than one type of test in studies of memory.

On a deeper level (sorry!), these observations indicate that the value of a particular activity depends upon the type of task one is performing. Semantic processing aids retention, but only if the semantic processing is appropriate to the retention test that is administered. If a rhyme test will be administered, then semantic processing will be less useful than phonemic processing.

Another problem confronting the levels of processing model concerns the degree of expertise or knowledge of the subject (Bransford et al., 1979). For example, we are all experts in recognizing the sounds of our native language. We remember the sounds of many words and the voices of many speakers over long periods of time. Similarly, we are skilled readers. Kolers and Ostry (1974; Kolers, 1979) have shown that people can remember over long periods of time the type of print they have read. The model fails to explain how people remember physical properties over long periods of time. Of course, one could argue that they do so by processing the physical information deeply. But this argument breaks down the distinction between nonsemantic and semantic processing. Additionally, it is difficult to measure exactly the level at which processing occurred. This problem is examined next.

THE PROBLEM OF DEFINING DEPTH

In most experiments, the depth of processing is defined by the type of incidental learning task that the subject performs. For example, if the task requires phonemic processing, then it is assumed that the subject engages in phonemic processing. The problem with this assumption is that the subject may engage not only in phonemic processing but also in semantic processing (Nelson, 1979; Postman, Thompkins, and Gray, 1978). Because of our extensive experience in processing words semantically, for example, in the act of reading, we may automatically process words at the semantic level even in tasks that require only phonemic processing. So it is unwise to define the level of processing in terms of the requirements of incidental learning tasks.

In the absence of an adequate method of measuring the level of processing, we may be tempted to infer the level of processing from the observed level of retention. High levels of retention might indicate the occurrence of semantic processing, whereas low levels of retention might indicate the occurrence of nonsemantic processing. But taking this step robs the model of its explanatory power. If we attribute the high retention to deep processing, when the only evidence of deep processing is the high retention, we are trapped in a vicious circle (Baddeley, 1978; Eyesenck, 1978; Nelson, 1977; Postman, 1976).

To eliminate the problem of circularity, we need to define the level of processing without referring to the level of retention. Investigators have tried hard to formulate such a definition. Some have examined whether deeper processing is indicated by relatively long processing times (Craik and Tulving, 1975; Kunen, Green, and Waterman, 1979) or by the extensive use of processing resources (Eyesenck and Eyesenck, 1979; Tyler, Hertel, McCallum, and Ellis, 1979). Others have tried to define depth by subjective ratings of the level of processing (Seamon and Virostek, 1978). Yet these attempts have met with little success. For now, the problem of defining levels empirically remains unsolved.

TWO KINDS OF REHEARSAL?

The model asserted that Type I processing, also called maintenance rehearsal, maintains information at a particular level of processing but does not improve retention. Type II processing, also called elaborative rehearsal, analyzes information at progressively deeper levels, thereby improving retention. We saw previously that some observations support this distinction. For example, the number of times subjects rehearsed words, supposedly as part of a distractor task, did not influence the level of recall (Rundus, 1977). This outcome seems to indicate that maintenance rehearsal does not improve retention.

Other experiments, however, have shown that maintenance rehearsal can improve retention (Geiselman and Bjork, 1980; Glenberg and Adams, 1978; Maki and Schuler, 1980; Nelson, 1977; Woodward et al., 1973). Glenberg et al. (1978) presented numbers to be remembered in each of a series of trials in an immediate memory task. During the retention intervals, the subjects repeated particular words, supposedly as a means of preventing rehearsal. At the end of the session, the subjects were asked unexpectedly to recall all of the words. As Rundus had observed, the number of rehearsals of a word did not influence the level of recall. But a test of recognition showed that rehearsal did facilitate recognition. Using a similar experimental procedure, Rundus (1980) observed that if the rehearsal occurred over a period of 60 seconds, a longer period than had been used in earlier studies, then rehearsal facilitated recall by a small but significant margin.

These observations initially seem to oppose the view that maintenance rehearsal does not affect retention. But owing to the problems involved in defining levels of processing, these observations are difficult to interpret. Perhaps the subjects in the preceding experiments engaged in elaborative rehearsal even though the task did not demand it. If elaborative rehearsal did in fact occur, then these results pose no problem for the model. Yet it is difficult to tell whether the subjects had engaged in maintenance rehearsal, elaborative rehearsal, or both.

In light of this uncertainty, it is unsurprising that theorists disagree about whether there are two different kinds of rehearsal. Some have argued in favor of retaining a modified version of the distinction, claiming that the two types of rehearsal influence retention through different processes (Geiselman and Bjork, 1980; Rundus, 1980). Specifically, elaborative rehearsal may involve processing items at progressively deeper levels and relating the meanings of the various items that are being processed. Maintenance rehearsal, on the other hand, involves linking the rehearsed items with the external or internal contextual cues that are present. For example, as a word is rehearsed, it may automatically become associated with the sights and the sounds in the experimental room, with the subjects' feelings of hunger, and so on. If those cues are present in the retention test, then they may facilitate the retrieval of the rehearsed words. Other theorists, however, contend that a strict dichotomy between two kinds of rehearsal is untenable (Craik, 1979; Craik and Jacoby, 1979; Jacoby, Bartz, and Evans, 1978). They favor replacing the dichotomy with a continuum of rehearsal activities that influence retention in various degrees. Additional research must decide which of these conceptions is most useful.

STAGES RECONSIDERED

A major problem of the model was that it envisaged a fixed sequence of processing stages that began with physical analyses and terminated with semantic analyses. As was shown in the discussion of attention, however, we often process in a conceptually driven manner in which deep semantic analyses precede and guide the analysis of physical features. For example, in reading the sentence *The name of our planet is 'earth,'* we may begin processing semantic information pertaining to our planet before actually seeing the word *earth*. And when our eyes encounter *earth*, we may process at a semantic level and use the results to guide the analysis of the physical features of the word. In conceptually driven processing, deeper analyses precede and guide shallower analyses. This processing sequence is just the opposite of the sequence proposed by the model.

These problems necessitated the revision of the model. The revised model disavowed the concept of a fixed sequence of processing stages, yet it retained much of the flavor of the initial model. We now examine the revised model, which centers around the concept of the elaborateness of processing.

Elaboration, Organization, and Mnemonics

The revised model states that retention depends not on the depth of encoding but on the elaborateness or the spread of encoding (Craik and Tulving, 1975). The elaborateness of encoding refers to the extent to which items are related to or organized with other items. For example, in learning a list of words that includes *grief, love, forgotten,* and *spinster,* you could encode *spinster* in a relatively elaborate manner by relating it to the other words, perhaps by making up a story that included all of the words. You might encode *spinster* in a less elaborate manner by analyzing the meaning of that word without relating it to the meaning of the other words. This definition of elaborateness emphasizes the relationships between different items.

Elaborateness also refers to the extent to which an individual item is analyzed, regardless of the level at which the processing occurs. For example, *spinster* has numerous semantic attributes or features, including *female, unmarried,* and *old.* The more attributes we encode, the more elaborate our memory representation is. Whereas the first definition emphasized between-item elaboration, this definition stresses within-item elaboration. These definitions point out that information can be elaborated in at least two ways, both of which occur by adding information to the internal representation.

One reason behind the emphasis on elaborateness is that the elaborateness of processing affects retention apart from the level of processing. Craik and Tulving (1975) asked subjects whether briefly presented words such as *watch* made sense in various sentences, for example, *He dropped the* ______ and *The old man hobbled across the room and picked up the valuable* ______ *from the mahogany table.* Both sentences require processing at the semantic level. But the latter sentence requires richer, more elaborate encoding because it provides more semantic context than the former sentence. The results of an unannounced memory test showed that the more elaborately the words had been processed, the higher the level of retention was. This kind of observation has convinced many theorists that retention depends less on the level of processing than on the elaborateness of processing (cf. Cermak and Craik, 1979).

The elaborateness concept is preferred also because it avoids the notion of a fixed sequence of processing stages (Craik and Tulving, 1975). Phonemic analyses can occur before physical analyses have been completed, and semantic analyses can occur before phonemic analyses have

been completed. For example, in reading an article about the chimpanzee, you might process the physical and the phonemic features of the word *chimp* minimally, while processing the semantic features elaborately. After all, in reading, we attend primarily to the meaning of words rather than to their physical and phonemic properties. Under other conditions, for example, in evaluating the rhythm of a poem, you might process the physical features of the words elaborately while processing the meanings minimally.

Unlike the initial model, this conception states that elaborate processing facilitates retention regardless of whether the processing involves physical, phonemic, or semantic analyses. Indeed, if the physical processing is more elaborate than the semantic processing, as occurs in evaluating the rhythm of a poem, this conception predicts that the physical information will be remembered better than semantic information. Nevertheless, this conception retains the central idea that the manner in which information is encoded determines the level of retention. Keeping this similarity in mind, we now examine the effects of the elaborateness of processing on retention. We begin with a discussion of between-item elaboration and return subsequently to within-item elaboration.

ORGANIZATION IN FREE RECALL

One way to process an item elaborately is to group that item with other items, that is, to organize the items. As a demonstration, read the following list of words at a slow rate, about 2 to 3 seconds per word. Then close the book and write down as many of the words as possible in any order.

> Bear, cucumber, fox, chair, turnip, dog, stool, radish, bed, sofa, squash, rabbit, tomato, monkey, carrot, lamp, cow, broccoli, table, mouse, lettuce, dresser, desk, horse

In recalling this type of list, most people recall the words by category. You probably tended to recall the animals together, the vegetables together, and the furniture items together. This phenomenon, which was studied by Bousfield (1953), is called *categorical clustering.* It shows that we tend to organize items into groups as we learn.

Early experiments tested whether organization facilitated retention. For example, Tulving (1962) presented a list of 16 two-syllable nouns at a rate of one word per second. The words in the list were unrelated in that they did not belong to similar categories, and they were not highly associated. When the list had been presented, the subjects were asked to recall the words in any order. Then a second trial began, and the procedure was repeated except that the words were presented in a different order. This procedure continued over ten trials. Tulving measured the degree of organization by measuring the extent to which pairs of words were recalled together across trials. The rationale was that if a subject recalled two words, for example, *building* and *cent*, one after another on successive trials, then one could assume that the subject had organized those words in a stable group.

Over trials, both the number of words and the level of organization increased. Because the words in the list were not related in any obvious way, the subjects may have imposed organization on the list as they learned it. This phenomenon, called *subjective organization*, is consistent with the Gestalt outlook that learning is a process of actively imposing structure upon incoming stimuli. Equally important, this observation suggests that organizing facilitates remembering. Of course, a positive correlation between the level of organization and the level of retention does not imply that increased organization causes improvements in retention.

In an effort to obtain stronger, noncorrelational evidence, investigators have examined the effects of inducing organization. One way to induce organization is to present the items in a manner that calls attention to the semantic relationships between the items. For example, Bower, Clark, Lesgold, and Winzenz (1969) asked subjects to remember 112 words that belonged to one of four conceptual hierarchies. One of the hierarchies included the names of minerals, as shown in Figure 4.5a. This type of arrangement is called a conceptual hierarchy because it contains

Minerals

Metals			Stones	
Rare	Common	Alloys	Precious	Masonry
platinum	aluminum	bronze	sapphire	limestone
silver	copper	steel	emerald	granite
gold	lead	brass	diamond	marble
	iron		ruby	slate

(a)

Brass

Ruby			Gold	
Granite	Steel	Lead	Iron	Sapphire
minerals	limestone	metals	masonry	alloys
emerald	rare	precious	aluminum	diamond
copper	stones	slate	common	platinum
	silver		bronze	marble

(b)

Figure 4.5 The hierarchies presented by Bower et al. (1969). (a) The conceptual hierarchy for "minerals." (b) A random arrangement of the words in (a).

conceptually related groups of items arranged in such a manner that each higher-level category subsumes the categories beneath it. The subjects in the organization group saw the words arranged on cards as in Figure 4.5a. This type of arrangement was intended to call attention to the relationships between the words and to encourage the subjects to organize the words. The subjects studied four different hierarchies, each of which included 28 words, for 56 seconds in each of four trials. An identical procedure was followed for the control group, except that the words on each card had been placed randomly in a hierarchy, as in Figure 4.5b. This arrangement did not highlight the conceptual relations between items.

The results were that following the first study period, the subjects in the organization group recalled 73 of the 112 words. But the subjects in the control group recalled only about 20 words. Following four trials, the subjects in the organization group recalled all 112 words, whereas the subjects in the control group recalled only half that number. Additionally, the recall profiles showed that the subjects in the organization group recalled the items in a highly organized manner. They usually started at the top of the hierarchy and then worked downward branch by branch of the hierarchy. For example, they tended to recall *minerals*, *metals*, and *rare* before recalling *platinum* and *silver*. This organized pattern of recall was not apparent in the recall profiles of the subjects in the control group. These observations establish that organization does facilitate memory. Many other observations agree with this conclusion (Bower, 1972).

There are numerous reasons why organization aids memory. As pointed out in the preceding chapter, encoding items into groups reduces the burden on our limited processing resources. As resources are freed, we can find or construct new relations between the items to be remembered and the information we already remember (Mandler, 1979). The eventual outcome is improvements in learning and retention.

Three other reasons concern the retrieval of information. First, when several items have been combined into a single group or chunk, retrieving one member of the group may make the others more accessible. A physical analogy is that finding one book in a library provides access to other related books nearby. Second, when items have been encoded in a group, there may be multiple retrieval paths into the group (one path per item), and this might enhance the retrievability of the information. Third, when items have been organized into a hierarchy, as in the preceding experiment, the hierarchical structure can be used as a plan that guides the retrieval of each branch of the hierarchy. The elaborateness of encoding, then, may influence retention largely by facilitating retrieval. This interpretation emphasizes the close relation between encoding and retrieval.

MNEMONICS

Additional evidence concerning the effects of the elaborateness of encoding comes from studies of mnemonic systems, devices designed to aid memory. For example, Bower and Clark (1969) instructed subjects to learn lists of ten words by making up a story that linked the words together. The subjects managed to connect the words in stories, as in this example:

> A LUMBERJACK DARTed out of a forest, SKATEd around a HEDGE past a COLONY of DUCKS. He tripped on some FURNITURE, tearing his STOCKING while hastening toward the PILLOW where his MISTRESS lay.

Subjects in a control group had not been instructed to use the story mnemonic, but they studied the lists for the same length of time. Following the learning of 12 lists, the subjects were asked to recall all of the words that they had studied. Impressively, the subjects in the story group recalled 93 percent of the words, whereas the subjects in the control group recalled only 13 percent of the words.

An alert skeptic might argue that these observations can be explained in terms of the depth of processing rather than the elaborateness of processing. Perhaps the subjects in the story group had processed the words semantically whereas the subjects in the control group had processed the words nonsemantically. The results of other experiments, however, have reduced the plausibility of this account (Battig and Belleza, 1979). Belleza, Richards, and Geiselman (1976) presented a list of words and asked subjects to use each word in a separate, meaningful sentence. The subjects in the story group were asked to weave their sentences into a continuous story. The subjects in the control group used each word in a sentence but did not try to combine the sentences into a story. Both tasks required semantic processing. Yet the subjects in the story group recalled a greater number of words than the subjects in the control group. So the effects of using the story mnemonic are better explained by the elaborateness of processing than by the depth of processing.

Another mnemonic that involves elaborate processing is called the *keyword system* (Atkinson, 1975). This system, which was designed to facilitate the learning of the vocabulary of a second language, consists of two steps. The first is to associate a vocabulary word with a rhyming English word called a keyword. For example, if the vocabulary item presented were *pato*, the Spanish word for *duck*, one could use *pot* as the keyword. Having associated *pato* and *pot*, one would then form an image of the keyword interacting with the English translation of the vocabulary item. One might imagine a duck swimming in a large pot or perhaps a duck marching around with a pot on its head. In summary, the keyword system involves associating a vocabulary word with a rhyming English word, the keyword, and then imagining the keyword and the English translation word interacting.

This system, like many mnemonics, may seem like the long and hard way of doing things. Yet the system has been shown to be highly effective (Presley, Levin, Hall, Miller, and Berry, 1980). Atkinson (1975) asked subjects to learn 120 Russian words. Half the subjects learned and used the keyword system, whereas the other subjects received no formal instructions. The two groups received equal numbers of study sessions. The results were that the subjects who used the keyword system recalled the meaning of 72 percent of the Russian words, but the other subjects recalled the meanings of only 46 percent of the words. On a surprise test given six weeks later, the subjects who had used the keyword system continued to outdo the others.

The keyword system probably aids performance by encouraging elaborate phonemic and semantic processing. Elaborate phonemic processing occurs by associating a vocabulary item with the similar sounding keyword. This phonemic processing is particularly useful because learning to pronounce words correctly is often one of the largest obstacles to learning foreign vocabulary. Elaborate semantic processing occurs while imagining the object named by the keyword interacting with the English translation of the vocabulary item. In forming an interactive image, one relates different items to each other. On this view, the benefits of forming interactive images, as in the method of loci that was discussed in the first chapter, stem from the occurrence of elaborate processing.

As we learn more about memory and about why elaborate processing is so effective, we should be able to invent useful new mnemonics and to improve existing ones. It is hoped these will help to advance our educational practices and to reduce the frequency of forgetting. Some educators object to the use of mnemonics because many mnemonic systems resemble tricks that do not promote comprehension of underlying concepts. But this seems less a constraint on mnemonic systems than on our ingenuity, for carefully designed mnemonics can stimulate the elaborate semantic processing that educators have always tried to encourage.

Elaborateness and Distinctiveness

We now turn to the effects of within-item elaboration, that is, the extent to which an individual item is analyzed. The memory codes we form may be thought of as groups of attributes or features from numerous dimensions (Bower, 1967; Nelson, 1979; Underwood, 1969; Wickens, 1972). For example, if you encountered the word *skyscraper*, you might process the sound and the meaning of the word, thereby forming a memory code containing phonemic and semantic attributes. The greater the number of attributes of an item you have analyzed, the more elaborately you have encoded that item.

If the elaborate processing aids memory, then an analysis of several attributes of an item should lead to better retention than an analysis of only one attribute. In order to test this prediction, Battig and Einstein (1977; also see Battig, 1979) asked subjects to rate words along one, two, or three dimensions. For example, one of the dimensions concerned the pleasantness of words; the subjects used a six-point scale to indicate the degree of pleasantness or unpleasantness of the words. Two days later, the subjects were asked to recall the words they had rated. As predicted, the subjects recalled a greater number of the words they had rated on three dimensions than of those they had rated on one or two dimensions. These observations suggest that the degree of within-item elaboration influences retention.

DISTINCTIVENESS

As discussed previously, elaborate processing may aid memory by facilitating the retrieval of information. Many investigators believe that elaborate processing makes items distinctive or discriminable from other items and that the increased distinctiveness aids retrieval (Eyesenck, 1979; Jacoby and Craik, 1979). A physical analogy clarifies this view. If a coach asked you to get a particular basketball from a storage room, you would be more likely to find the correct ball if you had a complete description rather than a partial one. The complete description would provide information that distinguished the desired ball from the others. Similarly, an elaborate memory code provides a relatively complete description of the remembered item. For this reason, the item is relatively distinctive and easy to discriminate from other remembered items. As a result, the item can be retrieved more accurately than a less distinctive item can be.

Eyesenck (1979) examined the effects of distinctiveness by inducing either distinctive or nondistinctive coding at the phonemic level of processing. In the nondistinctive condition, the task was to pronounce a series of words in the usual manner. The words were nouns, for example, *glove,* that could be pronounced in the usual manner (gluv) or in an unusual manner (glōve, which rhymes with *cove*). In the distinctive condition, the task was to pronounce the words in the unusual manner. On a subsequent recognition test, the subjects remembered a greater number of words from the distinctive condition than from the nondistinctive condition. Distinctive processing at the phonemic level, then, increased retention.

In further experiments, Eyesenck showed that distinctive processing at the phonemic level can lead to the same high level of retention that results from semantic processing. Thus the distinctiveness of encoding can override the effects of the level of encoding. This type of observation poses problems for the initial levels of processing model. Now that we have examined the revisions of that initial model, we may reinterpret some of the observations discussed earlier.

DEPTH EFFECTS RECONSIDERED

In a typical study of levels of processing, subjects are induced to encode information at either of two levels, for example, the phonemic and semantic levels. As you know, semantic processing often leads to superior retention. This outcome may be due to the depth of encoding, but it may also be due to differences in the elaborateness and distinctiveness of encoding. In particular, semantic processing may give rise to more elaborate and distinctive encoding than phonemic processing does (Anderson and Reder, 1979; Moscovitch and Craik, 1976). Because we belong to a literate society, we have all had extensive practice in processing words semantically and remembering themes. Reading, for example, requires that we discern the semantic relationships between words in sentences, between sentences, and so on. As well-practiced readers, we may encode semantic information elaborately with little effort or conscious thought. In contrast, we are seldom called upon to process the sounds of the words we hear elaborately. Consequently, in a study of levels of processing, adults may automatically encode semantic information elaborately and nonsemantic information nonelaborately. Consistent with this view, semantically processed words tend to be recalled in organized clusters, whereas nonsemantically processed words tend not to be (Hyde and Jenkins, 1973).

This account, which stresses the importance of prior experience and elaborate encoding, makes interesting predictions. Presumably, people such as poets who have had extensive experience in discerning the relationships among the sounds of printed words would automatically encode elaborately on the phonemic level. These individuals should remember phonemically processed words as well as semantically processed words. Following similar logic, professional musicians might be expected to remember the physical features of songs better than laypeople do. To the knowledge of the author, no one has tested these predictions. But studies should be conducted to determine the relationship between practice and the effects of the elaborateness of encoding.

Semantic processing may also give rise to more distinctive, elaborate encodings because of the nature of the tasks often used in studies of levels of processing. Answer each of the following questions. Do *bear* and *bare* rhyme? Do *distill* and *remove* have the same meaning? Answering the first question required the comparison of two sounds, and there is little if any reason to process elaborately. But the second question calls for some elaborate processing. Words have many senses and shades of meaning, and the second question can be answered accurately only when all possible meanings have been analyzed. In short, question two requires elaborate processing whereas question one does not. Although this particular comparison is extreme, the point applies to many other examples. Tasks that induce different levels of processing may also induce different degrees of elaboration, and it may be the latter that influence memory.

The view that elaborate processing facilitates memory is useful and is currently guiding extensive research. Yet this view must overcome several obstacles. We lack adequate measures of elaborateness and distinctiveness. Consequently, it is difficult to determine the exact relationship between elaborate processing and retention. Similarly, we cannot say exactly how elaborateness and distinctiveness are related. Theorists have only begun to test the hypothesis that elaborate processing aids retention by increasing the distinctiveness of the remembered information. But research along these lines is now under way, and this should increase our understanding of remembering.

METAMEMORY

Remembering often occurs as a by-product of incidental processing. But in many situations, remembering results from deliberate, conscious efforts. For example, we write notes to remind ourselves what to buy while shopping, and we place particular items near the door in order to remember to take them with us when we leave. Similarly, in studying for a history test, we may intentionally rehearse key dates, imagine pivotal episodes, organize events according to temporal sequence, and so on. These examples show not only that we often remember intentionally but also that we know how to remember. This knowledge or awareness of how to remember is called metamemory or metamnemonic knowledge (Flavell and Wellman, 1977).

Our metamnemonic knowledge is important because it enables us to tailor the manner in which we process to the demands of the task. Most adults have many different strategies for encoding information, but not all of the strategies are equally appropriate in a particular task. For example, if the task were to read and remember the theme of a novel, then a semantic coding strategy would be more effective than a phonemic coding strategy. Without metamnemonic knowledge, people would fail more frequently than they already do to use appropriate coding strategies. As a result, they would be more forgetful and would appear less intelligent. Because of the importance of metamemory, this section focuses on our knowledge of how to remember and analyzes where this knowledge comes from.

Broadly speaking, metamemory includes our knowledge about our

memory skills, about the determinants of our performance in memory tasks, and about how to monitor and modify our activities so as to remember. These and other components of metamemory are best thought of as components of problem solving (Brown and DeLoache, 1978). In this instance, the problem is how to remember something. Accordingly, we shall group the components of metamemory into categories corresponding to the broad steps involved in solving a problem: defining the problem, planning a strategy for solving it, and monitoring and adjusting performance in accord with the outcomes. In this section, we focus on the first two steps since they have been studied extensively.

Awareness of the Mnemonic Problem

The mnemonic problem, the possibility that we may forget something worth remembering, is pervasive in everyday life. Who has not had the experience of walking into a test confident of remembering the critical information only to leave feeling shell-shocked and deflated? Recognizing the mnemonic problem requires awareness of the goal of remembering something and assessing whether special effort is needed to meet the demands of the present memory task. In turn, making this assessment requires considerable knowledge of our own memory skills and knowledge and of the factors that make a memory task difficult (Flavell and Wellman, 1977). As we shall see, this knowledge arises through experience; its absence is often conspicuous in young children and inexperienced adults.

KNOWLEDGE OF PERSON VARIABLES

Awareness of a memory problem can arise from knowledge about the scope and limits of one's own memory and of human memory in general. Through our experiences, we know the difficulty of remembering large amounts of poorly learned information. Yet the limits on the span of immediate memory are not so apparent to young children. In one experiment (Yussen and Levy, 1975), 4-, 8-, and 20-year-olds were shown a set of ten pictures and were asked to estimate how many they thought they could recall on an immediate retention test. As shown in Figure 4.6, the youngest children were quite inept in predicting their actual memory span. For the 20-year-olds, on the other hand, there was little discrepancy between the predicted and the actual memory span. Having such accurate knowledge enables the adults to discern memory problems that the 4-year-olds would not have noticed. Although 4-year-olds do recognize the memory problem in some situations (Acredolo, Pick, and Olsen, 1975), their knowledge of their own memory skills is understandably limited.

The adults' knowledge of their actual memory span may have arisen

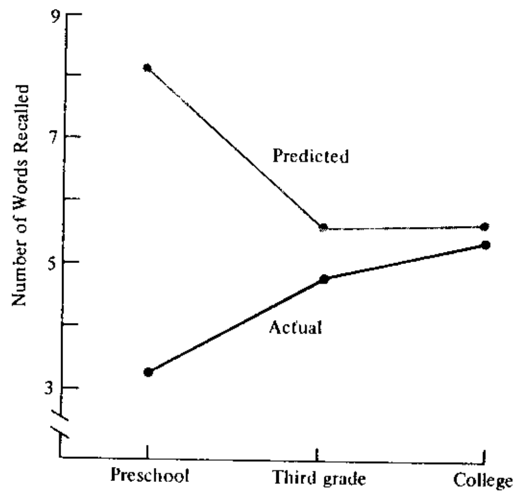

Figure 4.6 Predicted and actual memory spans of people at various ages. (Data from Yussen and Levy, 1975.)

from the understanding that, in general, the span of immediate memory is limited to about seven items. Each of us acquires extensive knowledge about the general properties of human memory, even in the absence of formal instruction in psychology. We learn in school that all students must study in order to remember the presented information. We learn from our families that the elderly are often forgetful, that the young cannot be expected to know their exact memorial abilities, and so on. This knowledge of the memory skills of large groups of people can help us discriminate memory problems in ourselves as well as others.

Some of the most important metamnemonic knowledge we have pertains to our own memorial idiosyncrasies and propensities. For unknown reasons, some people can effortlessly remember names and faces, whereas others must struggle to remember names but have impressive memories for numbers. Some people, such as the preoccupied "absent-minded professor" find themselves so forgetful that they fastidiously take notes (which they promptly lose) on almost every important event. These examples illustrate long-term or dispositional memory characteristics. As we learn more and more about our own characteristics, we become aware of and anticipate the memory problems we face in various situations. In addition to knowing our long-term characteristics, we know about the effects of short-term conditions upon our memory. Through our unique experiences, we may learn that lack of sleep begets a general forgetfulness or that we tend to forget things heard in a moment of indisposition. This knowledge may also help us to identify and anticipate memory problems.

KNOWLEDGE OF TASK VARIABLES

Adults in our culture have extensive knowledge about the variables that influence the difficulty of a memory task. We know that long retention intervals produce more forgetting, and that large quantities of information are more difficult to remember than small quantities are. Similarly, we know that retention depends on the type of memory test. Specifically, recall of the gist or theme of a passage is usually easier than verbatim recall. The differences in the difficulty of various types of test are particularly well known to students. Some students have even been known to use the type of test as a criterion for choosing courses. Without a doubt, this knowledge of task variables enables adults to discriminate the occasions on which memory problems are likely to occur.

Knowledge of the task variables that influence memory is hardly restricted to adults. In one type of study (Kreutzer, Leonard, and Flavell, 1975; Myers and Paris, 1978), children were told a story about a girl who had been asked to listen to a record so that she could later repeat what the record said. The story ended by the girl asking whether she could tell the story in her own words or had to recall it word for word. The children were asked whether verbatim recall or recall of the gist would be easier. Selection of gist recall as easier than verbatim recall increased sharply from kindergarten through fifth or sixth grade. Also, the fifth- and sixth-graders were able to say why the girl in the story had asked about the type of test. These results raise the possibility that increased experience in school leads to increased metamnemonic knowledge.

Another important type of task variable concerns the characteristics of the stimuli to be remembered. Adults recognize readily that it is easier to learn a list of familiar words than a list of unfamiliar nonsense syllables. Similarly, we know that a list of words divided into obvious semantic categories such as *fruit* and *names* is easier to remember than a list of semantically unrelated words. This knowledge is particularly interesting because it pertains to learned characteristics of the stimuli, not to external characteristics. The ability to judge the extent of our internal knowledge rather than simply assess external variables arises through experience. For example children often fail to predict that semantically related words will be better remembered than semantically unrelated words will be (Kreutzer et al., 1975; Moynahan, 1973). Ability to make such predictions increases as children receive more experience in school.

At present, we do not know exactly how schooling and other aspects of experience lead individuals to discriminate which task variables influence retention. We should recognize, however, that parents, teachers, and peers often provide instructions concerning which task variables influence memory. Parents tell us to make a list of the items needed at the store because "there are too many things to remember." Teachers often tell students that the tests given so far have been easy but that future tests will require verbatim retention and will be much harder. Instructions such as these may increase the child's awareness of the task variables associated with memory problems. Equally important, the instructions point out that active steps must be taken to avoid forgetting. This instruction probably helps children to learn to plan a strategy for remembering.

Planning a Mnemonic Strategy

Becoming aware that a particular memory problem exists is only the first step toward deliberately alleviating the problem. In order to take effective action, one must also know that what one does can alleviate the problems. That is, one must realize that one's own cognitive activities can prevent or minimize forgetting. In addition, one must be able to plan a course of action, to choose an appropriate strategy, that will overcome the memory problem.

The difference between these two facets of planning a strategy is illustrated by the following experiment (Appel, Cooper, McCarrell, Sims-Knight, Yussen, and Flavell, 1972). Children were shown a series of pictures following either of two types of instructions. The memory instructions indicated that there would be a retention test for the pictures. The other instructions told the children to look at the pictures since doing so would facilitate performance on a subsequent task. The two types of instructions led 11-year-olds to engage in very different activities and to recall the picture better following the instructions to remember. In contrast, 4-year-olds did not respond differently to the two sets of instructions, and they recalled an equal number of items in the two conditions. Seven-year-olds recalled about the same number of pictures in the two conditions, but the instructions did have some effect. The memory instructions led the 7-year-olds to name the stimuli often, whereas the instructions to look did not have that effect. Apparently, the 7-year-olds knew they had to do something to prevent forgetting, but the activities they chose were ineffective. So knowing that one must plan a course of action and choosing an effective strategy are two different things.

THE VARIETY AND APPROPRIATENESS OF STRATEGIES

Choosing an effective strategy for overcoming a particular memory problem depends partly on having various strategies to choose from. Adults do have many strategies, and these may be divided into two categories: internal and external (Kreutzer et al., 1975). Internal strategies involve engaging in internal activities such as imaging and rehearsing to facilitate memory. External strategies involve acting on the external environment in ways intended to facilitate memory. We use external strategies when we write lists of things to remember, when we put objects in places where we will probably see and remember them, and when we ask others to remind us to do particular things. As you might expect, young children often have fewer mnemonic strategies at their disposal than older children and adults do (Kreutzer et al., 1975). No doubt this difference in knowledge of strategies contributes to the performance differences between children and adults on both memory and metamemory tasks.

A second prerequisite for adopting an effective mnemonic strategy is the ability to distinguish between strategies that are appropriate or inappropriate to the tasks at hand. If the task called for remembering many intricate, briefly presented pictures, a strategy involving verbal coding and rehearsal would probably fail. That same strategy, however, might be useful in remembering a telephone number for a short time. In general, judging the appropriateness of a particular strategy requires knowledge about stimuli, task variables, one's own knowledge, and, of course, one's skill in using the strategy.

STRATEGY DEVELOPMENT AND APPLICATION

As discussed above, choosing an effective strategy demands that several strategies be available and that the individual recognize which strategies will succeed. Two key questions concern how adults acquire various strategies and how they recognize which strategies will work in which tasks. Researchers have not yet answered these questions, but some useful information has come from studies of rehearsal in children.

There are marked developmental differences in the knowledge and use of rehearsal strategies (Ornstein and Naus, 1978). Children of 5 years and under seldom rehearse spontaneously, whereas 7-year-olds and older children do so readily (Flavell, Beach, and Chinsky, 1966). Differences occur not only in the amount or frequency of rehearsal but also in the type of rehearsal. When second-graders rehearse, they tend to repeat one item at a time, with little apparent effort at relating the various items that have been presented. In contrast, sixth-graders rehearse items in groups of three or four; this elaborative rehearsal leads to a high level of retention (Ornstein and Naus, 1978; Ornstein, Naus, and Stone, 1977). Similarly, 13-year-olds rehearse the members of a particular category together, whereas 8-year-olds and younger children do not (Ornstein, Naus, and Liberty, 1975).

The failure of young children to rehearse does not stem from an inability to do so. Young children do rehearse when they are explicitly instructed to do so, and the increased rehearsal does improve retention (Keeny, Cannizo, and Flavell, 1967; Ornstein et al., 1977). Why is it, then, that young children do not usually rehearse on their own? The answer to this question is unknown, but spontaneous rehearsal is unlikely to occur unless the following two conditions have been met earlier in the child's lifetime. First, rehearsal must have been made to occur. Second, the memorial consequences of rehearsal must have been effective in maintaining the rehearsal activity.

Both of these conditions seem to be satisfied in formal educational settings. Before children in our society have entered school, they probably have not had extensive memory demands placed on them. The demands they do face can often be satisfied through the use of strategies other than rehearsal. For example, the task of remembering to bring a baseball to the playground can be performed by putting a baseball near the front door. Indeed, young children tend to think of such external strategies rather than internal ones such as rehearsal (Kreutzer et al., 1975). In school, however, external strategies are often prohibited; when taking tests, we are expected to rely on our internal resources. Further, many of the stimuli we are told to remember in school are verbal and well-suited for rehearsal (how else is one to remember multiplication tables?). These factors, together with the strong incentives that teachers and parents provide for remembering in school, set the stage for the use of the rehearsal strategy.

Children often begin rehearsing as the result of what teachers do. For example, the author learned to rehearse in the course of learning the familiar alphabet rhyme in first grade. The teacher would begin the jingle, encourage the students to follow along, and to practice saying it to ourselves. We were also told that we could remember the alphabet by simply repeating the rhyme. So, schooling seems to be important for inducing people to use internal verbal strategies. This conclusion is supported by cross-cultural research, which has shown that the use of verbal mnemonics such as organizing words semantically is correlated with the extent of formal education (Cole and Scribner, 1977).

When rehearsal has been induced, beneficial consequences may follow. The child who rehearses the alphabet and subsequently recalls the alphabet correctly might receive a high grade, the approval of the teacher and the parents, and so on. These positive consequences may lead the child to rehearse in future situations. Similarly, positive social consequences are often applied to teach the child the relation between rehearsing and remembering. For example, a teacher might ask a young girl how she plans to remember the names of the state capitals. If the girl said she planned to say them to herself over and over, the teacher might express his or her approval. This type of training might help children learn to observe their own activities and to intentionally plan particular strategies for remembering.

Continuing in the same vein, the social consequences of mnemonic activities may help teach the child to choose an appropriate strategy. Having learned to use the rehearsal strategy, the child may tend to apply it to tasks for which it is unsuited. The negative results might include poor performance on a retention test, a low grade on a test, and parental disapproval. By applying a particular strategy successfully in some situations but not others, children may learn to discriminate when the strategy will or will not work. These comments also apply to how adults come to recognize the appropriateness of various strategies.

As these comments indicate, cognitive strategies are molded by their consequences, and they operate in the service of social needs. Ultimately, cognition is both a product and a mainspring of social interaction.

• *Summary.* For nearly 20 years, the multistore model guided research concerning memory. The multistore model assumed that there are separate short-term and long-term memory stores. The short-term store had limited storage capacity and retained information for about 15 seconds. On the other hand, the long-term store had unlimited storage capacity and retained information for long periods of time, perhaps permanently. Through rehearsal, information was maintained in the short-term store and was transferred to the long-term store.

Numerous observations supported the assumption of separate short-term and long-term stores. Some people who had suffered brain damage had normal memory spans but often failed to remember new information over the long run. This observation suggested the existence of a separate short-term store. The two memory stores also seemed to differ with respect to coding. In immediate memory tasks, most subjects encoded information phonemically, that is, by sound. But in studies of long-term retention, subjects encoded information semantically. Additionally, in studies of free recall for lists of words, people remembered the first few and the last few words much better than they remembered the other words. The superior retention for the last few items, the recency effect, disappeared when a 30-second delay was imposed between the presentation of the list and the test of recall. But the superior retention of the first items, the primacy effect, was not influenced by the delay. It appeared that the primacy effect reflected long-term storage, whereas the recency effect reflected short-term storage. Consistent with this account, the subjects rehearsed the first few items more often than the last few items, suggesting that rehearsal transferred items from the short-term store to the long-term store.

The multistore model failed eventually. Investigators discovered that people retain not only phonemic information but also semantic and visual information in immediate memory. This observation undercut the coding distinction between the two stores. Other studies reported long-term recency effects. Experiments concerning rehearsal suggested that there were two kinds of rehearsal. Maintenance rehearsal maintained in-

formation in immediate memory but did not enhance long-term retention. Elaborative rehearsal, which involved relating the rehearsed items to one another, did enhance long-term retention. These results showed that rehearsal was not a simple transfer mechanism and that there may be different types of processing.

The multistore model was superseded by the levels of processing model, which disavowed the notion of separate short-term and long-term stores. The model stated that incoming information is analyzed in stages, beginning with the analysis of physical features and ending with the analysis of meaning and conceptual relations between items. The succession of stages is called depth of processing, where greater depth implies a greater degree of cognitive or semantic analysis. The thesis of the model is that the deeper the level of processing, the higher the level of retention. Consistent with this view, words that have been encoded semantically are remembered better than are words that have been encoded phonemically. Unlike the multistore model, the levels of processing model attributed the limited span of immediate memory to the limits on our processing resources, not to limits on the storage capacity of a short-term store. Further, the model held that there are two kinds of processing. Type I processing recirculated items at a particular depth of processing and did not aid retention, whereas Type II processing analyzed items on a deeper level and did aid retention. This conception allowed the model to account for the effects of the two kinds of rehearsal.

The levels of processing model encountered several problems. First, the notion of a fixed sequence of processing stages was too rigid. Second, the levels of processing were difficult to define, and the model was therefore difficult to test. Third, in retention tests that assessed memory for phonemic information, the level of retention was sometimes as high following phonemic processing as it was following semantic processing. Fourth, maintenance rehearsal was observed to increase the level of recognition, thereby questioning whether Type I processing had no influence on memory.

The subsequent revision of the model emphasized that retention depends on the elaborateness rather than the depth of processing. Elaborate processing can occur by relating incoming items to other incoming items or to remembered information. In studies of free recall, people spontaneously organize words into groups, and this elaborate processing is correlated with high levels of retention. Further, retention can be facilitated by inducing elaborate processing, for example, by making the organization of a list noticeable, by instructing the subjects to form interactive images or to link items together in a story. Elaborate processing can also occur by analyzing a greater number of features of an individual item, for example, by noting the different shades of meaning of the word *radical*. This type of elaboration can also aid retention, perhaps by providing a relatively complete description of the encoded item. In turn, the complete description makes the item distinctive and more retrievable. This emphasis on elaborateness has the advantage of avoiding the concept of a fixed sequence of processing stages while retaining the idea that the type of encoding determines the level of retention. This theme continues to be the dominant force in analyses of remembering.

Studies of the effects of coding on remembering show that people can encode information in a variety of ways, and they often adjust their coding strategies to meet the demands of particular tasks. This adjustment process is guided by the knowledge of how to remember, called metamemory. Metamemory consists of three related components that serve to detect and to resolve a memory problem, the possibility that we might forget something important. First, one must become aware that a memory problem exists; this requires knowing what one does and does not know, what one is likely to forget, and what the demands of the task are. Second, one plans a strategy such as rehearsing, imaging, or writing oneself a note for preventing forgetting. Effective planning requires having various strategies available and judging the appropriateness of particular strategies to the task at hand. Third, one monitors one's performance to determine whether the strategy should be continued, modified, or replaced. Skill in each of these areas arises through experience, particularly through training received in school. Of course, being aware of a memory problem and of how to solve it does not necessarily enable us to act accordingly. Although we view conscious thought as our guide, thought and action are separated by a gap too wide and significant to ignore.