To the three who matter most:

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INTEGRATING SEMANTIC AND EPISODIC MEMORY

▼ Reconstructive Memory and Semantic Integration
  - Bartlett's Research
  - Schemata
  - Eyewitness Memory and Testimony
  - Semantic Integration
  - Technical and Content Accuracy

▼ Propositions, Stories, and Semantic Networks
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▼ Scripts and Plans
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▼ An Integrated Model of Long-Term Memory
  - The Semantic-Episodic Distinction
  - ACT*
We must, then, consider what does actually happen more often than not when we say that we remember. The first notion to get rid of is that memory is primarily or literally reduplicative, or reproductive. In a world of constantly changing environment, literal recall is extraordinarily unimportant. . . . Remembering is not the re-excitation of innumerable fixed, lifeless and fragmentary traces. It is an imaginative reconstruction, or construction, built out of . . . a whole active mass of organised past reactions or experience, and . . . a little outstanding detail which commonly appears in image or in language form. (Bartlett, 1932, pgs. 204, 213)

Indeed, the primary reason for the widespread acceptance of the notion of schematic knowledge structures is that it is almost impossible to imagine how mental life could be managed without them. (Nisbett & Ross, 1980, p. 38)

Some years ago, I attended a psychology convention in Boston. One evening, a group of us went to a famous local seafood restaurant for dinner. After waiting a long time (the place was thick with psychologists), we were finally seated at our table and given menus. The waiter returned a few minutes later to take our orders, and we went through the awkward rigmarole of asking for separate checks (for travel-receipt purposes). A few minutes later, the waiter returned, and after a slight pause to get our attention, turned first to me and said “Your dinner comes to $18.75, sir.”

I recall vividly the thoughts that raced through my mind. The first one was that we, as a group, were being insulted (or maybe it was just me)—obviously, the waiter or the manager believed that we should have to pay for our meals right then, rather than being trusted to pay afterwards. Was it because we were out-of-towners, conventioners? Was it because we asked for separate checks? I remember thinking that I might try reasoning with the waiter, but couldn’t actually manage to sputter much more than “What? You mean . . . Why should we . . . ?” (cool under pressure!) All of this occurred to me very quickly, because it wasn’t but a second or two before the waiter, who had encountered such reactions before, continued by saying “It’s a long-standing tradition in this restaurant to have guests pay first. That way, you can enjoy the rest of your meal without having to think about the bill, and if you need to leave, you won’t have to wait” (that still strikes me as a weak argument, by the way).

I realized, of course, that my reaction had been ridiculous—I’d taken it personally, when in fact it was standard procedure. It was such a different procedure, however, from any I’d ever encountered, that I read much more into it than was called for. How would you have reacted in that situation? Even if your only thought had been “Gee, how strange,” think for a moment about the source of your reaction. Now consider your reaction in a slightly different situation, eating at someplace like McDonalds, where being asked to pay first is the norm, rather than the exception.

Having studied episodic and semantic memory separately in the previous two chapters, we now must put them back together again. It’s unreasonable, of course, to think that these two long-term memory systems are entirely separate, although cognitive psychology has studied them that way to gain an understanding of them in their “purest” form. But there is just as much interest in the interaction of semantic and episodic memories in the research, so that’s what we turn to now.

In the previous chapter, you read of a distinguishing feature of semantic memory research, that we test the subjects on the already-acquired knowledge that is brought to the laboratory. Episodic tasks, in contrast, present some specific, to-be-learned material to the subjects, then test their memory for that material. While the research presented in this chapter also presents specific materials to the subjects, there are at least two major differences from standard episodic memory situations. First, the material to be learned is meaningful. This means more than simply presenting a list of words as opposed to nonsense syllables—in the present chapter, we’re interested in how people remember a story, episode, or other real-world event. A second difference is in the typical results. Unlike the outcomes of many episodic memory tasks, the remembered information that we’re focusing on in this chapter is significantly influenced by semantic knowledge—by knowledge of concepts and relationships, by general information about the world, by our generic memory for episodic events. We have a term for this. When already-known information influences our memory for new events, we call it conceptually-driven processing. This is the overriding theme of the chapter—how remembering is affected by existing knowledge.

To gain some perspective on the material, let’s chart where we’re going in this chapter. We’ll begin with the topic of reconstructive memory and the research published by Bartlett in 1932 that was rediscovered by cognitive psychology in the 60s and 70s. This discussion will include the topic of “eyewitness testimony,” on the surface, a topic that might seem to fit better into the episodic memory chapter. At the conclusion of this section, we will turn to a discussion of memory for stories, and the more general topic of memory for connected discourse, especially written text. This will lead us directly to the topic of scripts, which are large-scale networks of interrelated knowledge about complex events and episodes we encounter in daily life. We will then conclude on two final issues: the ultimate utility of the distinction between episodic and semantic memories and a comprehensive model of semantic-episodic-procedural knowledge by Anderson (1983). The “production system” approach used by Anderson is a very useful way of thinking about many kinds of cognitive processes, not just remembering episodic and semantic information, so we’ll devote considerable space to that system. As you read, bear in mind the overall topic and theme of the chapter—we’re studying memory for meaningful material, and the influence of conceptually-driven processing.
\section*{Reconstructive Memory and Semantic Integration}

Figure 7-1 contains a story called "The War of the Ghosts," important not only because of the psychological points it raises, but also for historical reasons—Bartlett (1932) used it in one of the earliest research programs on remembering meaningful material. Please do the demonstration in the table now, before reading further.

Now that you have read and recalled the story, spend a moment jotting down some of the thoughts that occurred to you as you read and then tried to recall it. For example, if you remembered some specific details, comment on what made those details more memorable to you. Did you get most of the story line correct, or did you have to do some guessing? What was your sense of the story as you read it? You no doubt thought to yourself what a peculiar story it was, with all sorts of unfamiliar names and characters, with vague and hard-to-understand twists of the story line, and with unexplainable events. The story is a North Pacific Indian folk tale, so it's not surprising that it differs so much from "normal" stories you are familiar with.

Once you've exhausted your intuitions, turn to Figure 7-2 and compare your recalled version with the retellings in the table. While your version

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{image1.png}
\caption{Read the following, then attempt to reproduce the story by writing it down from memory.}
\end{figure}

Two young men from Egulac went out to hunt seals. They thought they heard war-cries, and a little later they heard the noise of the paddling of canoes. One of these canoes, in which there were five natives, came forward towards them. One of the natives shouted out: "Come with us: we are going to make war on some natives up the river." The two young men answered: "We have no arrows."

There are arrows in our canoes," came the reply. One of the young men then said: "My folk will not know where I have gone." But, turning to the other, he said: "But you could go." So the one returned whilst the other joined the natives. The party went up the river as far as a town opposite Kalama, where they got on land. The natives of that part came down to the river to meet them. There was some severe fighting, and many on both sides were slain. Then one of the natives that had made the expedition up the river shouted: "Let us return: the Indian has fallen." Then they endeavored to persuade the young man to return, telling him that he was sick, but he did not feel as if he were. Then he thought he saw ghosts all round him.

When they returned, the young man told all his friends of what had happened. He described how many had been slain on both sides.

It was nearly dawn when the young man became very ill; and at sunrise a black substance rushed out of his mouth, and the natives said one to another: "He is dead."

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{image2.png}
\caption{First recall, attempted about 15 minutes after hearing the story:}
\end{figure}

Two young men from Egulac went out to hunt seals. They thought they heard war-cries, and a little later they heard the noise of the paddling of canoes. One of these canoes, in which there were five natives, came forward towards them. One of the natives shouted out: "Come with us: we are going to make war on some natives up the river." The two young men answered: "We have no arrows."

There are arrows in our canoes," came the reply. One of the young men then said: "My folk will not know where I have gone." But, turning to the other, he said: "But you could go." So the one returned whilst the other joined the natives. The party went up the river as far as a town opposite Kalama, where they got on land. The natives of that part came down to the river to meet them. There was some severe fighting, and many on both sides were slain. Then one of the natives that had made the expedition up the river shouted: "Let us return: the Indian has fallen." Then they endeavored to persuade the young man to return, telling him that he was sick, but he did not feel as if he were. Then he thought he saw ghosts all round him.

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\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{image3.png}
\caption{Second recall, attempted about 4 months later:}
\end{figure}

There were two men in a boat, sailing towards an island. When they approached the island, some natives came running towards them, and informed them that there was fighting going on on the island, and invited them to join. One said to the other: "You had better go. I cannot very well, because I have relatives expecting me, and they will not know what has become of me unless you have no one to expect you." So one accompanied the natives, but the other returned.

There is a part I can't remember. What I don't know is how the man got to the fight. However, anyhow the man was in the midst of the fighting, and was wounded. The natives endeavored to persuade the man to return, but he assured them that he had not been wounded.

I have an idea that his fighting won the admiration of the natives. The wounded man ultimately fell unconscious. He was taken from the fighting by the natives. Then, I think it is, the natives describe what happened, and they seem to have imagined seeing a ghost coming out of his mouth. Really it was a kind of materialisation of his breath. I know this phrase was not in the story, but that is the idea I have. Ultimately the man died at dawn the next day."

Two retellings of the "War of the Ghosts," reported by Bartlett (1932).

may be closer to the original, because so little time passed between reading and recalling, you should be able to see points of similarity to the table retellings.

\section*{Bartlett's Research}

Bartlett (1932), not unlike Ebbinghaus, wanted to study the processes of human memory with the methods of experimental psychology. Very much unlike Ebbinghaus, however, he wanted to study memory for meaningful material, so he used folk tales, ordinary prose, and pictures in his investigations. His typical method had subjects study the material for a period of time, then recall the material several times, once shortly after study and then again at later intervals. By comparing the subjects' suc-
successive recalls, Bartlett examined the progressive changes in what his subjects remembered. Using these methods, Bartlett obtained evidence that human memory for such meaningful material is not especially reproductive, that is, it does not reproduce or recall the original passage in any strict sense of those terms. Instead, Bartlett characterized this sort of remembering as “an effort after meaning.” The modern term for this is reconstuctive memory, in which we remember by combining elements from the original material together with existing knowledge.

Two particularly notable aspects of Bartlett’s results led him to this conclusion. The first aspect concerns omissions, or what the subjects failed to recall. For the most part, people in Bartlett’s studies did not recall many details of the story, either specific names (Eugene, for instance), or specific events in the narrative (the phrase “His face became contorted,” for instance). The level of recall for the main plot, the overall sequence of events, wasn’t too bad, but minor events were often omitted. As a result, the retellings of the story are considerably shorter than the original. Of course, the subjects were not asked for verbatim (word-for-word) recall, so rephrasing and condensing is to be expected. Nonetheless, there were significant and widespread losses of information in the recall protocols.

The second aspect of Bartlett’s results is more fascinating. There was a strong tendency for the successive recalls to normalize and rationalize the occurrences in the story. That is, subjects showed an overwhelming tendency to add to and alter the stories, to supply additional material that was not contained in the original. These changes often had the effect of making the story more “normal,” conventional, or reasonable. It seems safe to suppose that the story was quite strange to Bartlett’s subjects, his friends and colleagues in Great Britain, so it is not especially surprising that their retellings had the effect of modernizing and demystifying the original (notice how the ghost theme becomes progressively less prominent in the two retellings in Figure 7–2, even though “ghosts” is part of the title of the story). What is fascinating about this result is the source of this additional material. Where did it come from, if not from the story itself? It came from the subjects’ memories.

Schemata

Bartlett borrowed the idea of a schema to explain the source of these adjustments and additions. In his use of the term, a schema was “an active organisation of past reactions or past experiences” (1932, pg. 201).

"I strongly dislike the term 'schema.' It is at once too definite and too sketchy... it does not indicate what is very essential to the whole notion... I shall, however, continue to use the term 'schema' when it seems best to do so, but I will attempt to define its application more narrowly" (Bartlett, 1932, pp. 200–201). The widespread use and sketchiness of the term continued after Bartlett as well. Later in the chapter we will substitute the term script, which, at least currently, has a more definite connotation.

essentially what we’ve been calling general world knowledge. More generally, a schema is a stored framework or body of knowledge about some topic. Bartlett claimed that when we encounter new material, such as the "Ghost" story, we try to relate the material to existing schemata (the plural of "schema"). If the material does not match an existing schema, then we tend to alter the material to make it fit. Our recall, then, is not a true, exact recall or reproduction of the original material. Instead, it is a reconstruction based both on elements from the original story and on our existing schemata.

What do we have here? We have a seemingly simple task, "read this story then recall it," which we might expect to lead to a relatively pure episodic memory ("I remember reading the story about ghosts, and it goes like this..."). But then we turn to the results and we find that, unlike typical recall results in episodic tasks, subjects are remembering things that weren’t there. The source of these remembered things must be the subjects’ memories, their knowledge—however vague—of events such as “Indian warriors doing battle” and so forth. An unimaginative way of looking at these results would be to claim that prior information, stored in memory, is exerting an interfering effect on current memory performance. We called it proactive interference in chapter 5 (see also Dempster, 1985). A much more intriguing perspective is that normal comprehension takes place within the context of an individual’s entire knowledge system, and that efforts to understand and remember meaningful material involve one’s own meaning system or general knowledge of the world. In short, what we already know exerts a strong influence on what we remember about new material.

More recent research has fleshed out some of the details of this generalization, and has added to our understanding of the importance of existing knowledge or schemata. For example, knowledge of the theme or topic of a passage improves people’s memory of the passage (e.g., Bransford & Johnson, 1972; Dooling & Lachman, 1971). On the other hand, providing a theme, say, by attaching a title to a reading passage, can also distort recall or recognition in the direction of the theme. A clever demonstration of this was provided by Sulin and Dooling (1974). One group of subjects read a paragraph about a fictitious character: “Gerald Martin’s seizure of power. Gerald Martin strove to undermine the existing government to satisfy his political ambitions. Many of the people of his country supported his efforts...” (p. 256). A second group read the same paragraph, but the name Adolf Hitler was substituted for Gerald Martin. After a five-minute waiting period, subjects were shown a list of sentences and had to indicate whether each was exactly the same, nearly the same, or very different from one in the original story.

Preexperimental knowledge, that is, existing knowledge about Hitler, led to significant distortions in the subjects’ recognition of sentences. Subjects who read the Hitler paragraph rated sentences as ‘the same’ more frequently when the sentences matched their existing knowledge about..."
Hitler, even though the original passage contained no such information (e.g., “Hitler was obsessed by the desire to conquer the world” p. 259). Furthermore, these thematic effects, as they were called, grew stronger in the group that was tested one week after reading the story.

This thematic effect was particularly striking in a second experiment that Sull and Dooling conducted. One group read an account of Carol Harris ("Carol Harris was a problem child from birth. She was wild, stubborn, and violent...). Only 5% of the subjects in this group said “yes” one week later when asked if the sentence, “She was deaf, dumb, and blind” had been part of the passage. In a contrasting group, the same paragraph was presented, but the name Helen Keller was used. Fully 50% of these subjects said “yes” one week later to the same critical question. The same pattern of results was also obtained by Dooling and Christianen (1977), in which subjects were told that the paragraph about Carol Harris that they had read a week before had, in fact, been about Helen Keller. Just as before, subjects responded “yes” to statements that referred to thematically consistent information, as if they were drawing inferences from their existing knowledge rather than remembering the passage on its own terms. Dooling and Christianen concluded that thematic effects are quite prominent during retrieval, at the time of test, since they were observed a full week after exposure to the passage.

Kintsch (1977) has pointed out that such results argue that recall for connected, meaningful passages is “neither reproductive nor constructive nor reconstructive, but all three” (p. 363). Immediately after reading, recall is fairly accurate, in other words reproductive, especially for less exotic passages than “The War of the Ghosts.” Note, however, that thematic inferences are still observed here, particularly when the title or topic of the passage “invites” the reader to draw such inferences. Later testing, especially when the topic or theme is already familiar to the subject, shows even more prominent reconstructive effects.

Finally, constructive effects, to use Kintsch’s (1977) term, refer to drawing inferences from the passage during the original comprehension process. For instance, Sull & Dooling’s subjects no doubt inferred that it was the German government being undermined in the Hitler story. If they did so at the time of original reading, then the constructive memory effect should influence all later retrieval attempts. If the inference was only drawn at the time of retrieval, however, then the thematic effects would be part of reconstructive memory. In general, it can be quite difficult to disentangle inferences drawn during original comprehension from those drawn during retrieval (but see Frederiksen, 1975), unless performance is tested both immediately after comprehension and then again at a later time (and even this introduces another complexity, since recalling a passage once will influence a second recall attempt).

These are complex and important ideas, and we’ll return to them again throughout this chapter and in chapter 9, where the combination of semantic and linguistic knowledge is discussed. For now, note that a prominent feature of the results in all of these studies is that existing knowledge can exert a tremendous influence on our memory for meaningful material. As a normal byproduct of understanding, we relate new information to the general knowledge already stored in memory. Subsequently, our performance in a memory task is based both on the new information and on general knowledge. It is probably impossible to find a more convincing example of conceptually-driven processing than this, the effect that existing knowledge has on current comprehension. And, since a new episode is being influenced by existing semantic knowledge, this line of research demonstrates clearly the topic of this chapter—the integration of episodic and semantic memories.

**Eyewitness Memory and Testimony**

A recent program of research by Loftus and her colleagues has expanded this generalization, and in the process has suggested some possibly disturbing conclusions about the reliability of eyewitness testimony. To the generalization that “what we already know exerts a strong influence on what we remember” we can add “and, what happens after that can also influence what we remember.” As If Bartlett’s research weren’t enough to call into question our ability to remember faithfully, Loftus’s research clearly demonstrates distortions in what is eventually recalled, depending on what has happened in the meantime.

Loftus began this line of research by examining the effects of “leading questions,” that is, questions that tend to suggest to the individual what answer is appropriate. This is the report we used to start our discussion of semantic memory in chapter 6. Loftus and Palmer’s (1974) subjects were shown films of car accidents and were asked to estimate the speed of the cars when they “smashed,” “collided,” “bumped,” “hit,” or “contacted” each other. As you learned, the stronger verbs led subjects to estimate higher speeds; the speed estimates are given in Table 7-1.

Loftus and Palmer pointed out that two interpretations were possible for this effect. One was simply a response bias interpretation, that subjects were uncertain of the exact speeds, so they biased their estimates in the direction implied by the verb. This, of course, is the “leading question” effect, that the phrasing of a question will bias the individual to respond in a certain way. While this possibility is obviously important when issues of trial testimony are considered, this was a somewhat less interesting possibility than the second interpretation. Rather than simply basing the subjects’ responses, it seemed possible that the question about speed had

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2 An early set of questions was, “Do you get headaches frequently, and if so, how often?” versus “If so, how occasionally?”. The “often” group reported an average of 2.2 headaches per week, the “occasionally” group reported 7 per week (Loftus, 1980, pg. 187). As I recall the anecdote, Loftus was interviewing potential candidates for an aspirin commercial with these questions, and ended up fibbing in one of the commercials herself. If memory serves, her TV ad began with the line “I teach college.” Readers are invited to draw the inference between aspirin and college teaching themselves.
were not asked about speed at all. As before, speed estimates were higher for the group that got the "smashed" film first. However, in this case, the subjects were not shown the smashed film in the series of questions, the critical item for the control group was "Did you see the car go through the glass?" whereas 60% of the subjects answered "yes" to the question, the control group believed the car had been travelling very rapidly—the proportion of subjects from the "smashed" group who had been exposed to the film was later confirmed by the authors. The proportion of subjects from the "smashed" group who had been exposed to the film was later confirmed by the authors of the study. The proportion of subjects from the "smashed" group who had been exposed to the film was later confirmed by the authors of the study. The proportion of subjects from the "smashed" group who had been exposed to the film was later confirmed by the authors of the study. The proportion of subjects from the "smashed" group who had been exposed to the film was later confirmed by the authors of the study. The proportion of subjects from the "smashed" group who had been exposed to the film was later confirmed by the authors of the study.

Table 7-1

<table>
<thead>
<tr>
<th>Verb</th>
<th>Average Speed Estimate</th>
</tr>
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<tbody>
<tr>
<td>Smashed</td>
<td>4.8</td>
</tr>
<tr>
<td>Collided</td>
<td>9.3</td>
</tr>
<tr>
<td>Bumped</td>
<td>1.0</td>
</tr>
<tr>
<td>Hit</td>
<td>3.0</td>
</tr>
<tr>
<td>Control</td>
<td>3.1</td>
</tr>
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</table>

Semantic Integration

Let's study a final research program within this general topic of reconstructive memory, another demonstration that related information becomes fused in memory. This third line of evidence is the well-known set of studies by Bransford and Franks (e.g., 1971; 1972). As before, this important set of results will be more sensible to you if you begin with the demonstration in Table 7–2..

Bransford and Franks (1971) were interested in the general topic of how people acquire and remember ideas, not merely individual sentences but integrated, semantic ideas. They asked their subjects to listen to sentences like those in Table 7–2 one by one, and then (after a short distractor task) answer a simple question about each sentence. After going through this procedure for all 24 sentences and taking a five-minute break, subjects were then given another test. During this second, surprise test, subjects had to indicate for each sentence whether it had been on the original list of 24 sentences or not, simply by deciding “yes” or “no”; they also had to indicate, on a 5-point scale, how confident they were about their judgments. In the terminology of such a recognition test, deciding that “yes” you have heard a sentence before is a judgment that the sentence is OLD; deciding “no” you haven’t heard it is a NEW judgment, i.e., “this is a new sentence that I haven’t experienced before.” Without looking back at the original sentences, take a moment now to make these OLD/NEW judgments about the sentences in Table 7–3.

All 28 sentences in this second test, termed the “recognition” test, were related to the original ideas in the first set of sentences. The clever aspect of the recognition test that Bransford and Franks devised, however, was that only four of the 28 sentences had in fact appeared on the original list—the other 24 were NEW. As you no doubt noticed in Table 7–2, the separate sentences were all derived from four basic “idea groupings,” for example “The ants in the kitchen ate the sweet jelly that was on the table.” Each of the complete idea groupings consisted of FOUR separate simple propositions: for example, (1) the ants were in the kitchen, (2) the ants ate the jelly, (3) the jelly was sweet, and (4) the jelly was on the table.

The original set of sentences (Table 7–2) presented six sentences from each idea grouping. Two of the six were so-called ONES, simple, one-idea propositions like “The jelly was on the table”; another two sentences were TWOS, where two simple propositions were joined, as in “The ants in the kitchen ate the jelly”; and finally, the last two were THREEs, as in “The ants ate the sweet jelly that was on the table.” Unlike original acquisition, when only ONES, TWOS, and THREEs had been presented, the final recognition test (Table 7–3) presented ONES, TWOS, THREEs, and the overall FOUR.

So what did Bransford and Franks find? Just as your performance probably indicated, Bransford and Franks’s subjects overwhelmingly judged THREEs and FOURs as OLD, in other words, they judged that they had seen them on the study list (just as you probably judged question 20, the FOUR, as OLD). Furthermore, as Figure 7–3 shows, they were very confident in their ratings. In other words, people were recognizing the sentences that expressed the overall idea grouping most thoroughly, even though they had not seen exactly those sentences during study. Such responses are called false alarms or false positives, saying “yes” when the correct response is “no.” On the other hand, subjects were not especially confident about having seen genuinely OLD sentences (e.g., #17 in Table 7–3). Furthermore, they had low confidence in their judgments about ONES, even though they had seen several sentences of that short
length (e.g., #9 in Table 7-2). Apparently, since those shorter sentences didn’t express the whole idea particularly well, subjects were less confident that they had seen them before.

What do these results suggest when considered in the light of Bartlett’s and Loftus’s demonstrations? Bransford and Franks (1971; 1972) con-

cluded that subjects had acquired a more general idea than any of the individual study sentences had expressed, that they “integrated the information communicated by sets of individual sentences to construct wholistic semantic ideas” (1971, p. 348, emphasis added; see also Loftus and Palmer’s subjects integrated related information into their memories for the car accidents, yielding a composite memory, as did Bransford and Franks’ subjects. All of the related ideas expressed in the individual sentences seem to have been fused together into one semantic representation, one memory record of the whole idea. In such a circumstance, it is not surprising that the subjects’ later recognition performance showed the pattern it did—they were matching the combined ideas in the recognition sentences to their memory representations, representations in which ideas were combined together. Rather than finding verbatim memory, Bransford and Franks found ‘memory for meaning’ or, memory based on the semantic integration of related material (see also Richardson, 1985).

Technical and Content Accuracy

Notice two general points here. First, recall or recognition of meaningful material seems quite unlike the recall and recognition we discussed in...
chapter 5. That is, episodic memory tasks generally look for, and find, performance based solely on the items presented as stimuli. This is a very heavily data-driven kind of processing. Occasionally, say in the clustering studies, subjects would recall information that hadn't been in the original list, for instance, "pear" intruding into recall of the fruit category. But for the most part, subjects involved in episodic tasks, in which nothing like the connected meaningfulness of a paragraph is presented, recalled what they were shown. Let's refer to this aspect of episodic performance as technical accuracy—subjects recall or recognize with some degree of accuracy, where accuracy is defined as recalling (or recognizing) exactly what was experienced. In a more semantic task, however, we find very little emphasis on, or evidence for, remembering exactly what was presented. Instead, subjects are remembering the material in terms of its overall meaning. When scored according to strict, verbatim criteria, technical accuracy ranges from not especially impressive (Bartlett's and Lottus & Palmer's results) to dramatically inaccurate (Brunsford and Frank's results).

The second general point here is more important. Technical accuracy is an unsatisfactory way of evaluating memory for meaningful material, as I think you'll agree. For one thing, it misses the important fact that subjects are remembering with a fairly high degree of accuracy—i.e., just a different kind of accuracy. Let's call this different kind of accuracy content accuracy, where accuracy here is defined as recalling (or recognizing) the meaning or content of what was experienced. The difference between these two terms is that technical accuracy stresses verbatim memory, while content accuracy stresses memory for concepts and ideas, the meaningful, semantic content of the material.

Which of these kinds of accuracy is more important? Well, it seems clear that each kind is important for different memory situations and demands. We should not dismiss technical accuracy too casually. I think our discussion of ecological validity in chapter 5 certainly suggests that some episodic memory experiments focused slavishly on technical accuracy, partly because meaningfulness was intentionally excluded from the studies. This, I believe, is a poor basis for rejecting technical accuracy as a goal, however. After all, there are countless situations in the real world in which technically accurate memory is important, Bartlett's opinion notwithstanding. If I forget the details of the procedure for saving a manuscript on my word processor, it doesn't help me at all to remember the concept of "save." Verbatim recall of my social security number, the classroom I teach in, and my mother's birthday are all essential, and content accuracy is insufficient in these cases. And of course, relatively ordinary passages, when tested immediately, can show relatively good levels of reproductive recall (e.g., Cofer, 1979).

On the other hand, there are also countless situations in which technical accuracy is not called for, or even would be considered very inappropriate; for instance, you ask a friend "Hey, what did Dr. Jones say in class yesterday?" and the friend responds with a verbatim retelling of the lec-

ture. In such situations, instead, recall of the gist or overall meaning of an event is more important—your ability to paraphrase correctly, for example, is a demonstration of content accuracy. You will not be asked for verbatim recall of this text on your exams, although you may memorize definitions of certain key concepts and terms verbatim. Instead, you are usually tested on content accuracy, on how well you have retained the ideas and concepts, and on how well you can express these ideas in your own words.

Even more to the point, consider Brunsford and Frank's subjects again, and the kind of memory system that produces false alarms to related sentences that had never been shown. Brunsford and Frank's subjects made false alarms to FOURS such as "The ants in the kitchen ate the sweet jelly that was on the table," said "Yes, I've seen this one before." Isn't this an instance of high, or even perfect content accuracy, despite the fact that only ONES, TWOS, and THREEs were originally presented? In other words, what general use would a memory system be to us if it didn't join related information together into a unified, composite idea? It would be absolutely debilitating if our memories didn't pull related information together, if they didn't notice the semantic relationships among separate ideas. If our memories couldn't do this, then in a sense we could never understand—we could only record isolated fragments in memory, without drawing connections among them. To reduce it to concrete terms, think how useless your memory would be if it didn't realize that the jelly that the ants ate was the same jelly that was on the kitchen table!
By focusing on content accuracy, a different perspective on memory and cognitive processes emerges, one that emphasizes how the memory system deals with meaningful, related information. Our memory system stores separate bits of information together to the extent that those separate bits are related to each other. We use what we already know—call it schemas, general world knowledge, or semantic memory—to understand new experiences in a conceptually driven fashion. Those new experiences then become part of our elaborated knowledge structures, and continue to assist later cycles of conceptually driven processing. Let’s call this the integrative memory tendency. One negative consequence of this tendency is that the separate bits of information may not match our existing knowledge completely, leading to certain kinds of distortions when we attempt to remember (Bartlett, 1932). Moreover, later retrieval may be technically inaccurate, a definite problem in situations like eyewitness testimony where verbatim accuracy is a goal (Neisser, 1981). An overwhelmingly positive consequence of this tendency, however, is that content accuracy is enhanced, that we can understand and remember complex, meaningful events and episodes.

Propositions, Stories, and Semantic Networks

If you’ll think for a moment about the kinds of experiments we’ve just been discussing, you’ll notice an interesting fact—in most or all of the reconstructive memory studies, we intentionally “lure” subjects into making mistakes (at least in the sense of technical accuracy). That is, we present meaningful material like a story, a paragraph, or even just a set of related sentences, then do something that “invites” mistakes of one sort or another. In the case of Bartlett’s work, subjects were given a peculiar story, much too long to be remembered verbatim, and filled with unusual events; in Loftus and Palmer’s case, subjects were lured into remembering a more (or less) severe accident by the verbs they read; and in the case of Bransford and Franks, however reasonable semantic integration is, it was clearly a “setup” to present sentences that were so unmistakably related.

This is not to say that such research is unrepresentative, biased, or in some other way unfair, underhanded, or misleading. Quite the contrary; there are many situations in everyday affairs in which related information lures us into remembering something that wasn’t in the original. Furthermore, it’s obviously important to understand how human memory can be influenced by such factors—after all, if you just read, if we didn’t store obviously related ideas together in memory, we could never genuinely understand. On the other hand, there is a more general kind of research in which semantic and episodic factors are combined, but the subjects are not deliberately misled. In this other kind of research, to which we now turn, we are merely interested in what subjects can recall when presented with ordinary connected prose. Putting it simply, aside from the occasionally distorting or misleading effects that existing knowledge can exert, what are the more ordinary effects of existing knowledge as we understand simple sentences, stories, and other forms of connected discourse?2

Propositions

Let’s begin with a basic unit of meaning, a semantic unit that represents the idea expressed in a simple sentence. By almost unanimous agreement, this basic semantic element or unit is the proposition. In chapter 6, the term proposition was defined as a simple relationship between two concepts. Here we drop the limitation to only two concepts and redefine proposition as set of semantic nodes connected by labeled pathways, where the entire collection of concepts and relationships expresses the meaning of a sentence. In Anderson’s (1985) terms, “A proposition is the smallest unit of knowledge that can stand as a separate assertion, that is, the smallest unit about which it makes sense to make the judgment true or false” (pp. 114–115). An example of a very simple proposition, one that is but a thought in your mind, is ROBIN has a RED BREAST, a simple combination of two semantic nodes connected by a labeled pathway. In a very real and accurate sense then, all connected pairs of concepts in semantic memory can be referred to as propositions. By extension, we can claim that semantic memory is an organized network of propositions, each representing a basic fact stored in memory.

The above characterization is entirely accurate, yet does not convey the true flavor of what cognitive psychology means by the term proposition. A more customary usage of that term is that a proposition represents the meaning of a sentence, say one that you read in a story or heard in a conversation. Just as we attempted to account for basic semantic knowledge in terms of a network structure, propositional theories attempt to account for our mental representation of the meanings of sentences as networks of interconnected propositions.

2The dictionary definition of “discourse” is: “communication of ideas, information, etc., especially by talking; conversation.” In cognitive psychology, we use the term to refer to any connected and meaningful sequence of words, from simple sentences up through paragraphs or, in principle, whole books. If anything, the connotation in cognitive psychology implies written instead of spoken language. A completely interchangeable term is connected text. As vague as these terms are, they serve the purpose of referring to the stimulus materials we present to subjects when studying how people understand and remember meaningful sentences, paragraphs, stories, etc. Further, they avoid the slightly behavioral connotation of the term “stimulus,” and they imply something longer and richer in meaning than “stimulus.” In some situations, the terms paragraph or story will be more precise, and will be used. In general, however, all of the research discussed in this chapter concerns connected discourse or connected text. Understanding such discourse or text is referred to as discourse processing or text processing.

3Notice that the sentence need not be a complete, grammatical sentence in order for us to generate its propositional structure; a phrase, for instance, or any meaningful fragment can also be represented in propositional format. For simplicity, however, we’ll deal only with full sentences here. We will also postpone the more linguistic aspects of propositions until the next chapter.
(1) The Hippe touched the beutenant in the park.

(2) She stepped him.

(3) (The TOUCH in #1 caused the STAMP in #2)

(4) So.

(5) For the two of them, the result was the same. (2)

(6) And that was a higher number.

(7) For a second pass, the program was identical. (2)

(8) The program was identical.

(9) That was the basic premise of the program. And what it can produce is the result.

(10) The Hippe, the beutenant, and the program were identical. (2)

(11) And that was a higher number.

(12) For a second pass, the program was identical. (2)

(13) The Hippe, the beutenant, and the program were identical. (2)

(14) So.

(15) For the two of them, the result was the same. (2)

(16) And that was a higher number.

(17) For a second pass, the program was identical. (2)

(18) The program was identical.

(19) That was the basic premise of the program. And what it can produce is the result.

(20) The Hippe, the beutenant, and the program were identical. (2)

(21) And that was a higher number.

(22) For a second pass, the program was identical. (2)

(23) The Hippe, the beutenant, and the program were identical. (2)

(24) So.

(25) For the two of them, the result was the same. (2)

(26) And that was a higher number.

(27) For a second pass, the program was identical. (2)

(28) The program was identical.

(29) That was the basic premise of the program. And what it can produce is the result.

(30) The Hippe, the beutenant, and the program were identical. (2)

(31) And that was a higher number.

(32) For a second pass, the program was identical. (2)

(33) The Hippe, the beutenant, and the program were identical. (2)

(34) So.

(35) For the two of them, the result was the same. (2)

(36) And that was a higher number.

(37) For a second pass, the program was identical. (2)

(38) The program was identical.

(39) That was the basic premise of the program. And what it can produce is the result.

(40) The Hippe, the beutenant, and the program were identical. (2)

(41) And that was a higher number.

(42) For a second pass, the program was identical. (2)

(43) The Hippe, the beutenant, and the program were identical. (2)

(44) So.

(45) For the two of them, the result was the same. (2)

(46) And that was a higher number.

(47) For a second pass, the program was identical. (2)

(48) The program was identical.

(49) That was the basic premise of the program. And what it can produce is the result.

(50) The Hippe, the beutenant, and the program were identical. (2)

(51) And that was a higher number.

(52) For a second pass, the program was identical. (2)

(53) The Hippe, the beunteer, and the program were identical. (2)

(54) So.

(55) For the two of them, the result was the same. (2)

(56) And that was a higher number.

(57) For a second pass, the program was identical. (2)

(58) The program was identical.

(59) That was the basic premise of the program. And what it can produce is the result.

(60) The Hippe, the beutenant, and the program were identical. (2)

(61) And that was a higher number.

(62) For a second pass, the program was identical. (2)

(63) The Hippe, the beutenant, and the program were identical. (2)

(64) So.

(65) For the two of them, the result was the same. (2)

(66) And that was a higher number.

(67) For a second pass, the program was identical. (2)

(68) The program was identical.

(69) That was the basic premise of the program. And what it can produce is the result.

(70) The Hippe, the beutenant, and the program were identical. (2)

(71) And that was a higher number.

(72) For a second pass, the program was identical. (2)

(73) The Hippe, the beunteer, and the program were identical. (2)

(74) So.

(75) For the two of them, the result was the same. (2)

(76) And that was a higher number.

(77) For a second pass, the program was identical. (2)

(78) The program was identical.

(79) That was the basic premise of the program. And what it can produce is the result.

(80) The Hippe, the beutenant, and the program were identical. (2)

(81) And that was a higher number.

(82) For a second pass, the program was identical. (2)

(83) The Hippe, the beutenant, and the program were identical. (2)

(84) So.

(85) For the two of them, the result was the same. (2)

(86) And that was a higher number.

(87) For a second pass, the program was identical. (2)

(88) The program was identical.

(89) That was the basic premise of the program. And what it can produce is the result.

(90) The Hippe, the beunteer, and the program were identical. (2)

(91) And that was a higher number.

(92) For a second pass, the program was identical. (2)
Simple sentences for forming propositional representations

(a) John went to Texas, and Douglas a jeep.
(b) "The man is driving a car." (A declarative sentence)
(c) "The man is driving a car." (A declarative sentence)
(d) "The man is driving a car." (A declarative sentence)
(e) "The man is driving a car." (A declarative sentence)
(f) "The man is driving a car." (A declarative sentence)

FIGURE 1.6

The ability to relate propositions to one another is critical to the verbal

(d) I don't think it's going to rain.
(e) I don't think it's going to rain.
(f) I don't think it's going to rain.

FIGURE 2.7

The ability to relate propositions to one another is critical to the verbal

(d) I don't think it's going to rain.
(e) I don't think it's going to rain.
(f) I don't think it's going to rain.

FIGURE 2.7

The ability to relate propositions to one another is critical to the verbal

(d) I don't think it's going to rain.
(e) I don't think it's going to rain.
(f) I don't think it's going to rain.

FIGURE 2.7

The ability to relate propositions to one another is critical to the verbal
Each sentence will be one of the propositions from the original sentence. For sentence (4), you should get three separate simple sentences:

(5) The lion was hungry.
(6) The lion ate Max.
(7) Max starved the lion.

3. Draw an oval to represent the overall node for each proposition, sentences (5) through (7), and number it to correspond to the simple sentence. Write the relation next to its oval, and connect node to the relation by an arrow labeled relation.

4. Add a node to each proposition for each argument, each noun or “nounlike” word in the proposition (ignore function words like “the”). To reduce the confusion, merely write the word next to the numbered proposition oval, instead of putting each word in its own oval. Two classes of nouns should be distinguished here. If a noun refers to a specific person or object, like Max, simply write the noun. If a noun refers only to an instance of a class noun, like lion, then create a new node, and give it an arbitrary name like X. The X will stand for this particular instance of the class noun; connect the X to its class noun with an isa arrow. If a noun occurs in two different propositions, use the same node for both instances; there should only be one Max node, even though Max occurs in both propositions (6) and (7).

5. Connect the proposition node to its arguments with arrows. Label the arrows with an appropriate semantic label, such as agent or subject, recipient, location, and so forth.

6. Rearrange the network to make it neat. In other words, there is no significance at all to the position of the nodes; the meanings are coded in terms of nodes that are connected, and the nature of the pathway or arrow that connects them.

Are Propositions Real? However theoretically elegant the propositional approach is in representing the meaning of connected discourse (and it is elegant), the ultimate test of the validity and usefulness of propositions is empirical (note that Artificial Intelligence, for example, would have a different opinion on what constitutes the appropriate ultimate test). It’s all well and good to have an objective, systematic, and reasonable way of representing meaning, as is provided by propositional-based theories of meaning (e.g., Anderson, 1978; Kintsch, 1974). Yet, if this approach weren’t supported by research results, it would be little more than an intellectual curiosity to cognitive psychology. Fortunately, a score of research reports have documented the psychological validity and utility of these hypothesized propositional structures. We’ll discuss only a very few, to give you the flavor of this important kind of research.

The basic idea in all of these tests is fairly straightforward. First, decide on the samples of connected text that are going to be presented, and ana-
lyze them in terms of their propositional structure. Having determined this structure, then further determine which portions of the structure are more important to an understanding of the passage, and which are less important—details of a minor episode, for instance, are relatively unimportant, but the overall outcome of a main episode is very important. Draw some predictions about recall, given what we know about the capacity of the memory system and the structure and importance of the elements in the passage. Finally, give the passages to subjects, and see what is and isn’t remembered, what is and isn’t distorted, and what is and isn’t invented.

**Remembering Propositions** Let’s begin with a classic study, one performed by Sachs (1967) before the advent of propositional theories. Sachs was testing a very general notion about memory—that people tend to remember meaning rather than superficial, verbatim information in the sentences they hear or read. Her subjects heard passages of connected text, and were then tested on one critical sentence in the passage, either 0, 80, or 160 syllables after the critical sentence had been heard (see Figure 7–8 for an example; why not read it now, and confirm Sachs’s results for yourself?) The test was a simple recognition test among four alterna-

![Image](image-url)

**FIGURE 7–8**

Read the passage below at a comfortable pace, but without looking back. After you have finished reading, your memory for one of the sentences in the paragraph will be tested.

There is an interesting story about the telescope. In Holland, a man named Lippershey was an eye-glass maker. One day his children were playing with some lenses. They discovered that things seemed very close if two lenses were held about a foot apart. Lippershey began experimenting and his “spyglass” attracted much attention. He sent a letter about it to Galileo, the great Italian scientist. Galileo at once realized the importance of the discovery and set about to build an instrument of his own. He used an old organ pipe, with one lens curved out and the other in. On the first clear night he pointed the glass toward the sky. He was amazed to find the empty dark spaces filled with brightly gleaming stars! Night after night Galileo climbed to a high tower, sweeping the sky with his telescope. One night he saw Jupiter, and to his great surprise discovered near it three bright stars, two to the east and one to the west. On the next night, however, all were to the west. A few nights later there were four little stars.

Now, without looking back, decide which of the following sentences occurred in the paragraph.

a. He sent Galileo, the great Italian scientist, a letter about it.
b. Galileo, the great Italian scientist, sent him a letter about it.
c. A letter about it was sent to Galileo, the great Italian scientist.d. He sent a letter about it to Galileo, the great Italian scientist.

Check to see whether your answers were correct by referring back to the paragraph.

Sample passage from Sachs (1967), along with the multiple choice recognition test for the critical sentence.

tives; one alternative was a verbatim repetition, one represented a change both in surface form and in meaning, and the other two represented changes only in surface form. When recognition was tested immediately, subjects were very good at recognizing (saying “yes”) to the accurate repetition—in other words, they noticed changes in superficial structure and changes in meaning. After comprehending the next 80 syllables’ worth of the passage, however, performance was accurate only in rejecting (saying “no”) to the one alternative that changed the meaning. In other words, subjects showed no preference for the repetition (d, the correct answer) over the superficially changed alternatives (a and c in the table) when the extra material intervened.

Sachs’s conclusions were straightforward—we very quickly lose information concerning the actual, verbatim string of words that we hear (or read), but we do retain the meaning. Our memory for the input then is based largely on the propositions. We reconstruct what must have been said based on the meaning that is stored in the propositional structure. Only in situations where there is something “special” about the verbatim string, say in recalling a joke, do we appear to retain surface form as part of our ordinary memory for meaningful discourse.

Confirmation of this last point was offered by Kintsch and Bates (1977), who gave a surprise recognition test to students either two or five days after a classroom lecture. Some evidence of verbatim memory was present after two days, but very little persisted five days afterward. As expected, verbatim memory for detail statements and extraneous comments was somewhat better than verbatim memory for general lecture statements. This was no doubt a von Restorff effect, as the authors noted; since there were very few detail and extraneous statements in comparison to lecture statements, memory for those infrequent (and therefore distinctive) statements was fairly good (see also Bates, Maing, & Kintsch, 1978). Even here, however, there seemed to be a role being played by reconstructive memory, and metamemory processes; students were better at rejecting items such as jokes that had not been presented than they were at recognizing jokes and announcements that had been heard (see also Brewer & Hay, 1984, on reconstruction of different linguistic styles).

Notice that these results are consistent with the propositional approach to meaning—Sachs’s subjects, as a current reinterpretation would say, were deriving a propositional structure of the passage they heard. They then retained only that structure, rather than the surface form of the sentences.

Gernsbacher (1985) has recently addressed the same phenomenon explicitly within the framework of propositional theories. In essence, she found the same results as Sachs did, both for verbal passages and picture stories (sequences of pictures that told a story nonverbally). Furthermore, Gernsbacher’s research tested several explanations of why we lose the more superficial aspects of what we hear or see. Her conclusion, for both kinds of passages, was that people have poor memory for surface infor-
mation because of processing shifts during comprehension. That is, as we comprehend the successive elements of a passage, we shift from building one propositional element to building the next one, then the next, and so forth. Each time we shift in this manner, information from the previous substructures that were built becomes less and less available, so that eventually the only information that remains is the propositional structure that represents meaning.

Kintsch has reported several direct tests of propositional theory, in particular the notion that a sentence with more underlying propositions is a more difficult sentence, hence harder to remember. In one set of studies (1974), short sentences were presented for simple free recall (five sentences were presented, followed by a two-minute recall interval, followed by another five sentences, etc.). The sentences had between two and four content words each, and from one to three propositions each. For instance, “The crowded passengers squirmed uncomfortably” and “The horse stumbled and broke a leg.” Both sentences have four content words, but the first sentence has three propositions whereas the second sentence has only two. Kintsch’s general predictions, based on propositional analysis, were upheld. Whereas subjects tended to recall about the same overall amount from all sentences, recall for the elements of any single proposition went down as the total number of propositions increased. Thus the more complex a sentence is, as indicated by the number of propositions it contains, the more there is to remember. Of course, with more to remember, less will be recalled.

**Propositions and Priming** At a more detailed level, a series of experiments by Ratcliff and McKoon has also confirmed the psychological reality of propositions, and has tied the notion of propositions to a task that you are quite familiar with, the priming task. Their experiments (1978) presented sentences to the subjects, then tested single words for recognition; i.e., subjects had to make yes/no decisions about target words, depending on whether the target word had been in the set of sentences or not. As an example, consider these two sentences: “Geese crossed the horizon as wind shuffled the clouds” and “The chauffeur jammed the clutch when he parked the truck.”

Two factors were examined, both related to the sequence of target words. First, a word might be followed by another word that had appeared in the same sentence, say horizon-clouds, or by a word from a different sentence, geese-clutch. The prediction, of course, was that the words from the same sentence would be represented more closely together in the propositional structures. In such a situation, the first word should serve as a prime for the second word, speeding the second RT. A second factor concerned words within the same proposition versus words from different propositions in the same sentence; some word pairs came from within the same proposition, like geese-horizon, and some from different propositions within the same sentence, geese-clouds. Obviously words within the same proposition should prime one another more than words from different propositions.

For both factors, the degree of relationship within the propositions influenced RT significantly. Words from the same sentence benefited 110 msec over words from different sentences. Considering just the words that came from the same sentences, those from the same proposition yielded a 111 msec priming effect, but words from different propositions yielded only a 91 msec priming effect. Thus, words from the same proposition benefited 20 msec more from priming than did words from different propositions within the same sentence. These results are viewed as strong support for the psychological reality of propositions, the idea that we comprehend by constructing propositional representations of sentences, then remember these propositions. As stored in memory, the words within a proposition are more closely related than words from different propositions, which in turn are more closely related than those from different sentences.

**Story Grammars**

Propositional representations have also been studied in more complex situations, particularly in those situations where an entire connected story is to be remembered. We’ll focus on just one program of research in this area, the story grammar approach of Mandler and Johnson (1977; also Mandler, 1978, 1984), although a variety of other studies would serve our purposes too (e.g., Torndyke, 1977; Trabasso & Sperry, 1985; Trabasso & van den Broek, 1985).

First, note the term story grammar. In psycholinguistics (see chapter 8), a grammar is a set of rules that generates or yields well-formed, acceptable sentences. Thus, a story grammar is a set of rules that specifies the structure of a well-formed story. Mandler and Johnson focused particularly on folktales, children’s stories, and the like, since these usually have a more clearcut organization than other narratives, and since they are more similar to one another than other story types tend to be. Mandler and Johnson set out to study the internal structure of such stories, and to write a grammar that not only would represent that structure, but also would provide an explicit basis for predicting what is remembered from such narrative passages.

**Story Structure** Consider the story in Figure 7–9, Mandler and Johnson’s (1977) “Dog Story.” The 11 numbered lines in the figure correspond roughly to the 11 ideas in the story, essentially the set of propositions that tell the tale of the dog whose greed got the better of him. Notice first that since the Mandler and Johnson’s work concerned much larger segments of text than just a few connected sentences, it’s not surprising that their propositions are somewhat larger than Anderson’s (for instance, proposition #3 in Figure 7–9 would be broken into several inter-
related propositions according to the rules you applied in Figure 7-7, with the relations cross, lie, and possibly an implied going for "on his way home"). The Mandler and Johnson propositions correspond to elements or plot-related concepts such as SETTING, EPISODE, CAUSE, and so forth. You might think of their story grammar model, then, as taking a less microscopic look at the individual words and concepts within sentences, and instead as focusing on more general connections among the complex elements or ideas represented in the story. Thus, at this general level, a well-formed STORY is composed of a SETTING and an EVENT STRUCTURE; an EVENT STRUCTURE consists of one or more EPISODES; and an EPISODE has a BEGINNING, CAUSE, DEVELOPMENT, CAUSE, and ENDING, and so forth. These rules in the grammar are listed at the top of Figure 7-10 along with the network diagram of the dog story.\footnote{You'll read more about grammars in the next chapter. For an intuitive feel, however, note that a FABLE in Mandler and Johnson's scheme is one notch higher in the grammar's rules, composed of a STORY and a MORAL; in other words, the only difference between a story and a fable is that a story merely concludes, whereas a fable follows the conclusion with an explicit moral. In the grammar, we would add one more statement: FABLE = STORY and MORAL. As an exercise, try turning the "Dog Story" into a fable by tagging on one final sentence.}

The first thing to notice in the diagrammed structure is that different nodes occupy different hierarchical locations within the structure of the story. In the grammar, the SETTING is a preliminary section that sets the stage and introduces the central character of the story. As such, even small children realize that the first line or so of a story is important in this introductory sense. In contrast, line #4 is another level "down" in the structure; it is subordinate to the first major element of the EPISODE, the BEGINNING. Another key feature is that nodes are related to one another in terms of their functioning within the overall structure, rather than in more superficial ways such as proximity of the ideas in the passage. As an example, lines #3 and #4 are adjacent in the original story, but are predicted to be considerably less related than #4 and #5 by the network structure (or than #8 and #10, for that matter, which are separated by another proposition in the input). This is, in some sense, analogous to the Ratcliff and McKoon result for words from the same or different propositions in a sentence. Finally, the terminal nodes in the diagram, the numbered nodes that correspond to the lines in the story, are at the "bottom" of the network structure—in other words, they are the basic ideas for each section of the network, ideas that are not reduced to a more particular idea, or are not further elaborated into more minor detail.

Predictions and Evidence  Mandler and Johnson developed several very specific predictions for the recall of stories, most of them dealing
with recall from well-formed versus less well-formed structures. For instance, a story that conforms better to the ideal structure will be recalled better than one that lacks one or more of the components, or one that asks the listener/reader to infer the component. Further, two events in a story that are connected by AND or THEN should be less well recalled than two connected by CAUSE. This prediction because the causal connection should bind two events together more strongly than AND or THEN; alternatively, we might expect more inversions of order for the AND and THEN propositions than we would for events connected by CAUSE. Another prediction involves the order of ideas within propositions. Inversions (reversals of order) within a basic node will be more frequent than inversions between nodes themselves. As an example, you might recall “He decided to get the meat that the other dog had,” inverting #6 and #7. You would be unlikely to invert these ideas with those in #4 and #5, where the dog sees his reflection in the water.

Mandler and Johnson studied four stories that differed in their structures, presenting the stories to subjects then asking for recall (after a 10-minute distractor task). Their predictions concerning recall of the stories were largely confirmed. For example, one of the four stories was a less well-structured tale, as analyzed by the grammar, with two incomplete episodes. Recall of this story was substantially below recall of the other three; adults recalled 88% of the basic nodes in three stories, but only 66% in the less well-structured story. Another prediction that was confirmed involved inversion. In the recall protocols, inversions between nodes were extremely rare, totaling only 2% of all basic nodes recalled; this is contrasted with a much higher rate of inversions between propositions (6.3%) and between phrases within propositions (14.7%). The theory also predicted that additions to the story, where the subjects add material not in the original, would tend to restore a less well-formed story structure to a more ideal form. Mandler and Johnson’s study (see also Mandler, 1978) also confirmed this prediction.

Two final aspects should be noted here. First, the Mandler and Johnson experiment also tested children in first and fourth grades, to see how their recall of the elements might differ. Even first graders gave clear evidence of the structural influence on recall, although their overall level of performance was lower than the older subjects’. “The most general description of the first-graders’ protocols is that they mentioned one or more of the main characters, the event that got the story going, and the outcome that resulted, omitting the internal reactions of the characters or what they did, as well as the final ending of the story” (p. 145; see also Mandel & Johnson, 1984).

Second, in a particularly nice twist, Mandler and Johnson “reached back” to the beginnings of this kind of investigation to Bartlett (1932). They analyzed Bartlett’s “Wer of the Ghosts” story with their grammar, and compared its structural representation with the recall protocols that Bartlett reported in his book. As you no doubt could guess, the “Ghosts” story is not particularly well formed: “A predominant characteristic of this story . . . is the presence of temporal relations where causal ones are expected . . . This should loosen the structure of the story and produce inversions and distortions in recall” (p. 139). Overall, the propositional network scheme that Mandler and Johnson developed gave a much more precise way of understanding people’s difficulty with the “Ghosts” story than Bartlett had been able to offer. Their story grammar and propositional representation showed how failures in recall were related to structural “defects” in the original story, and how additions served to “restore” the story to a more usual, ideal form.

**Propositions and Semantic Networks**

Look back for a moment at Figure 7-1, the propositional representation of the “Max” sentence. Do you see anything that resembles a semantic memory “entry” or concept in this network? Not really—we have the elements of the sentence diagrammed as three basic idea units, with the relationship among the three clearly indicated, yet there is nothing in the figure that gives a clue as to what a lion is, what starving means, or for that matter what kind of creature Max is. Look at Figure 7-10—do you see anything like “four legs, fur, isa animal,” and so forth connected to the “Dog” entry? Again, the answer is no. We have claimed that when people read or heard connective discourse, they construct a propositional representation of the input, yet there seems to be something missing. How would you know that a lion is a ferocious enough animal that, if provoked by starvation, it just might eat the person who starved it? What sense would the “Dog Story” make if you didn’t already know why a dog might want another piece of meat? The answer is that you wouldn’t if you only had the information diagrammed in Figure 7-1 or 7-10. They contain only a representation of the sentences in the input passages. What gives you this extra information? Semantic memory does, of course, the basic conceptual knowledge store.

Figure 7-1 shows a portion of the “Max” propositions, and a portion of the Mandler and Johnson (1977) “Dog Story” structure, but with a change. Now, these networks of propositions have additional pointers, arrows that connect the words in the propositions to their semantic memory representations. In essence, we’re saying that each node in the propositions has access to its own meaning representation in semantic memory. What does this access do? It provides the information necessary for constructing the propositions in the first place, for understanding the individual words in the sentences. From semantic memory comes the information that a lion is animate, a carnivorous creature capable of being the agent for the relation EAT; and for knowing that a dog, among many other things, eats meat. When Loftus and Palmer’s (1974) subjects understood their critical question, they accessed semantic memory as the prop-
each occurrence of a type node in a sentence—is a token node (think of the concepts in a sentence as being copies or tokens of the basic nodes in semantic memory). Thus, a proposition is composed of token nodes with directed pathways. Each token node in the propositions (including the relation) also has a linking pathway back to its type node (but only a few of these are shown in the figure, to avoid clutter). This link to the type node furnishes the meaning of the concept, since it ties the token into the entire semantic memory network.

We're not saying anything particularly radical here. We're merely claiming that when a sentence, story, paragraph, or other connected text is understood, there are two rather distinct memory representations that operate. First, the semantic concepts referred to in the input text are accessed. These word meanings are then used along with the input to construct a propositional structure for the entire passage, or in Kintsch's (1974) useful terminology, a text base. This text base, the network structure of propositions, represents the relationships among words in the sentence—who was the agent, the recipient, and so forth—depending both on the meanings of the words and the actual structure of the sentence. For instance, your semantic knowledge renders sentence (8) ridiculous, nonsensical in a nursery rhyme kind of way, or at least difficult to interpret:

(8) The mouse ate Max, who starved it.

Likewise, the different structures of sentences (9) and (10) dictate a very different “division of labor” among the agent/subject and recipient roles:

(9) The lion ate Max, who was starving.
(10) The lion, who was starving, ate Max.

At a general level then, the claim is that understanding connected discourse involves constructing a propositional representation of the text (e.g., Perrig & Kintsch, 1985). This process determines what roles the various concepts play in the sentence, how the propositions relate to one another, and, at a less microscopic level, how the propositions combine to give structure to the story or paragraph. Thus we have a generic, semantic network contributing conceptual knowledge to a more episodic task, the understanding and remembering of a passage of text. As time passes since the passage was read or heard, the superficial aspects of the sentences tend to fade away from working memory, probably from a combination of neglect and subsequent demands on processing capacity (e.g., Baddeley & Hitch, 1974; Craik & Lockhart, 1972). What remains, however, is a long-term memory representation of the meaning, a propositional structure that relates the ideas in the sentences to one another and to the basic meanings of the words as specified in semantic memory.
 Scripts and Plans

What still must be described is the large-scale semantic and episodic knowledge that accumulates in memory and guides our interpretation and comprehension of daily experience. These structures must be considerably more detailed than the rather simple semantic memory concepts we’ve discussed, since people know considerably more about the world than just the bare meanings of words. As the above demonstrates, you not only know about lions as basic entries in the wild animal category, but you can also infer much about them from other semantic and episodic knowledge as well. An example of that larger body of knowledge was illustrated at the beginning of the chapter, when the waiter at a restaurant asked the patrons to pay before getting their meal. The large-scale knowledge representations that support this comprehension and inference-drawing are called scripts.

Scripts in Memory

Think for a moment about the common meaning of the word “script,” the sequence of lines and actions that are to be (literally) performed by the actors and actresses in a play. The script for a play, in other words, details exactly what is supposed to happen in a stage production. In similar fashion, a mental script is a general knowledge structure about ordinary events and situations. In other words, a script is a mental representation of “what is supposed to happen” in a particular circumstance. Are you going to a restaurant? Your mental script tells you what to expect, what order the events will take, who the central characters are, and what you and they are supposed to do. Are you invited to a birthday party, taking an airplane flight, or sitting in a class on human memory and cognition? Your generalized knowledge of what happens in these settings guides your comprehension as the events unfold, and leads to certain expectations.

The overall theory behind the notion of scripts is quite straightforward: people record in memory a generalized representation of events they have experienced, and this representation is invoked, i.e., retrieved, when a new experience matches an old script. One function of a script, in either

a written or spoken story, is that it provides a kind of “shorthand” for the whole event—you need not describe each and every element of the experience, but can merely refer to the whole event by invoking the script. More importantly, the activated script provides a framework or context within which new experiences can be understood, and within which a variety of inferences can be drawn to complete your understanding (Abbot, Black, & Smith, 1985; Reiser, Black, & Abelson, 1985; Seifert, Robertson, & Black, 1985).

Let’s develop this notion of scripts with a few examples. Consider the following abbreviated stories (taken or adapted from Schank & Abelson, 1977, pp. 38–40):

11. John went to a restaurant. He asked for a hamburger. He paid the check and left.
12. John went to a restaurant. He asked the waitress for a hamburger. He paid the check and left.
13. John went into the restaurant. He ordered a Big Mac. He paid for it and found a nice park to eat in.

According to Schank and Abelson (1977), our understanding of stories (11) and (12) is guided by our scripted knowledge of a particular situation, going to restaurants; story (13) is understood by a particular variant or track in the restaurant script, the “fast food” track. In memory, these authors claim, are recorded a tremendously large number of separate scripts, generalized knowledge structures pertaining to routine, frequently encountered situations or events such as going to restaurants. Thus, the average adult, having experienced many different instances of “eating in restaurants,” has a generalized script representation of this situation.

Whenever we encounter a story like (11), elements of the story “trigger” or activate the appropriate script. As a consequence of this triggering, all subsequent events in the story (or events in a real-world experience) are interpreted with reference to the script that is activated in memory. In Schank and Abelson’s model, phrases or words that activate a script are called headers, which either name the script or refer to some semantically related concept that is part of the script. In a general sense, a header is nothing more than a prime, a concept that activates a related body of knowledge. Thus, headers like HUNGRY (John was hungry) or WAITRESS will activate the restaurant script, providing access to the entire body of “restaurant knowledge.”

In story (11) the explicit script name “restaurant” and the reference to a kind of food are sufficient to activate the script. Thus, the explicit reference to “the waitress” in story (12) is in some sense unneeded—res-
the rule goes something like this: If no detail was mentioned, assume the normal, default values as specified by the script; if a detail was mentioned, replace the default value with the detail. Thus, two plausible continuations of (14), one assuming the default value, and one not, might be:

(14a) Rather than go to his car to get his glasses, John asked the waiter to tell him what kinds of sandwiches they had.

(14b) But then the waiter told him that he wouldn’t need his glasses, since tonight’s dinner was a buffet.

**Predictions**

Figure 7-12 presents a simplified version of Schank and Abelson’s (1977) “restaurant script, coffee shop track,” as an indication of

![Figure 7-12](image-url)

Schank and Abelson’s (1977) depiction of the Restaurant Script-Coffee Shop Track, with props, roles, and scenes. (Adapted from Schank and Abelson, 1977.)
the generalized knowledge represented in such structures. Notice that an individual with no specific coffee shop experiences (for instance, a small child) will have no special track for this event, and will probably be guided by whatever more general restaurant script is available in memory. In such a case, we would expect either difficulties in comprehension, distortions in recall of a story based on the coffee shop track, or some other unusual processing of what is essentially a foreign experience. A more classic example of such difficulties in processing is presented in the story in Figure 7-13 (Bransford, 1979); be sure to make an honest effort to understand the story before you read the explanation in the bottom portion of the figure. As this passage shows, a story may activate a script but tier mismatch the expected events in the script. Depending on the severity of the mismatch, we would predict difficulties in comprehension and/or recall. On the other hand, if a person lacks a specialized track within the script, we would then predict comprehension based on the more general script that is in memory.

A final prediction from script theory is important enough that it needs to be developed in greater detail. Notice from the "shorthand" and default ideas above that everything need not be mentioned in a story for a person to understand. In fact, as Schank and Abelson (1977) put it: "When someone decides to tell a story that references a script, he recognizes that he need not (and because he would otherwise be considered rather boring, should not) mention every detail of his story. He can safely assume that his listener is familiar with the referenced script and will understand the story as long as certain crucial items are mentioned" (p. 38). In other words, the shorthand function of scripts relieves us of mentioning all of the slots or frames in the script. We can assume that the reader/listener will infer those unmentioned details by means of the stored script. A rather strong prediction then is that people's recall of a story will be influenced not merely by the details that were mentioned, but also by the events and details that were inferred based on scripted knowledge. As a simple example, if we developed a longer restaurant story, you might "recall" that the customer left a tip for the waitress, even though no tip was ever mentioned in the original passage. Where does the tip come from, so to speak? It comes from your script (the same place that the broken glass came from in Loftus and Palmer's "smashed" group). In short, these inferences come from long-term memory, from our semantic and scripted knowledge.

**Evidence for Scripts** Rather convincing evidence for these predictions has been collected in the past several years, and we will spend a few moments discussing that evidence (just as was the case for propositions, a script theory unsupported by empirical results would be of interest only to nonpsychologists). In fact, we have already encountered some evidence of this nature in the first section of the chapter on reconstructive memory. Why did Sulin and Dodling's subjects "remember" that they had read "She was deaf, dumb, and blind"? Because they were given the information that the story was about Helen Keller, and this information triggered the subjects' memory for information on Helen Keller.

Evidence specific to the script theory approach has been reported by Bower, Black, and Turner (1979); Graesser (1981); and Kintsch and van Dijk (1978), to name just a few. Let's focus on a paper by Smith and Graesser (1981) as a particularly good representative of such data. Smith and Graesser were investigating the role of typicality or relevance of specific events and actions in people's memory for script-based passages—do we remember the predictable events and actions better than the unpredictable, or is it the other way around? They presented a total of 10 passages to their subjects, each one related to a different scripted activity (taking the dog to the vet, washing a car, cleaning an apartment, etc.), and tested them with either a recall or recognition task. Tests were conducted 30 minutes after hearing the passages, then again after two days, one week, and three weeks. What made the Smith and Graesser evidence so compelling was the care they took in constructing their passages. Separate groups of subjects had provided lists of typical events and actions within each of the scripts, and the authors generated lists of atypical events and actions. All of these were then rated on their typicality by yet another group of subjects. The outcome of this was that passages were constructed to contain both typical and atypical events, permitting a detailed analysis of what was genuinely recalled, what was invented, and what was omitted.
At a general level, recognition was considerably more accurate than recall (not a surprising effect, of course) and performance dwindled across the retention interval (also not surprising). In the standard analyses of recall and recognition performance, typical information was remembered better than atypical information. These scores, however, were then corrected for guessing, since it is likely that high accuracy on typical information might include events that were genuinely remembered as well as events that were merely reconstructed from the script knowledge—reconstructions that were correct by chance, in other words. In these new analyses, recall and recognition scores were higher for atypical events than for typical events, after the reconstructed guesses were eliminated. In other words, in a story about taking the dog to the vet, subjects showed more accurate memory for the unusual, atypical events that occurred (for example, something like “While waiting for the vet, Jack dropped his car keys”). Typical events, those anticipated by the script (e.g., “Jack led the dog into the waiting room”), were recalled more poorly once the scores had been corrected for guessing (note that correcting the scores for guessing makes this a technical accuracy score, since content accuracy would not distinguish the presented from the reconstructed information).

This makes entirely good sense if you’ll spend a moment thinking about it. When you hear a script-based story, the script leads you to expect certain events and provides default values for them. For the most part, the typical events in Smith and Graesser’s work would be exactly those default values. Such default values don’t need to be stored in a memory trace for the story since they already are stored along with the script. On the other hand, the script does not prepare you for unusual or atypical events, like dropping the car keys. Thus, when it is time to recall or recognize the story, the atypical events have an advantage over the typical ones—the atypical events were specifically stored during comprehension, since they were details that could not have been anticipated by the script.

Graesser (1984; also Smith & Graesser, 1981) proposed a “Schema Copy Plus Tag” hypothesis to account for these results. It claims that a story that references a script leads us to store in memory a copy of the generic schema or script, plus specific episodic tags for unanticipated details that occurred. At the time of recall or recognition testing, performance depends on the stored representation. Information that was specifically tagged during input is readily available, accounting for the relatively high performance on atypical actions and events. Testing on more typical actions, however, reveals that no differentiation was made during input between events that were presented and events that were inferred from the script.

**Nakamura, Graesser, Zimmerman, and Riha (1985)** have recently tested this hypothesis in a more naturalistic setting, using a classroom lecture as the input, and a later memory test as the evidence. As was found with the prose passages, memory was better for the atypical or irrelevant information (e.g., sipping a cup of coffee) than for more typical information (e.g., underlining a word on the blackboard). Part of the strength of the Nakamura et al. paper is that it extends the script approach to settings beyond written or spoken passages. Another strength is that the results were obtained in a natural, “nonmemory” setting; the students were unaware at the time of the lecture that their memory would be tested for events that happened during the lecture. In other words, incidental memory in the Nakamura et al. study seemed largely the same as more intentional memory in the laboratory studies.

**Plans**

To conclude this section, what about situations that you’ve never experienced before, or situations that are so unfamiliar that you have no relevant script in memory? How do we comprehend such situations, or the connected discourse that describes them? According to many theorists, we not only have an extensive collection of relevant script knowledge in memory, we also have a generalized ability to plan. With this generalized ability, we can begin to understand situations where script knowledge is unavailable. In Schank and Abelson’s (1977) terms, scripts are the specifically acquired knowledge we use in dealing with the familiar world, whereas plans represent general knowledge. To illustrate, consider one final example from Schank and Abelson:

(15) John knew that his wife’s operation would be very expensive.

There was always Uncle Harry...He reached for the suburban phone book.

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It should be clear that we are talking about atypical but still plausible events, like dropping the car keys in the vet’s office. With highly implausible events, you get incoherence, something like the bizarre “Bransford Restaurant” in Figure 7-13.

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Last this be misinterpreted, the students were tested on their memory for incidental events during the lecture, not on the content of the lecture. What a shame that Nakamura et al. didn’t also test for some content information—it would have made an interesting comparison, whichever way the memory for content worked out.
Thus, a plan is a generalized strategy for achieving a goal. We do not store every conceivable experience and event as a script in memory, but only those we have experienced in some rather direct way. Understanding more novel situations is accomplished by means of our generalized ability to determine goals and to fashion plans that will accomplish the goals. It also depends, as we will see in chapters 11 and 12, on our ability to draw analogies—to detect similarities in otherwise different situations—and then base our plans on those similarities. Generally then, such comprehension relies on our abilities to plan and solve problems.

\[ \text{An Integrated Model of Long-Term Memory} \]

We have nearly completed a three-chapter look at long-term memory, its functions, structures, and processes. We first dealt with episodic and semantic memory separately, and now, as the title of this chapter implies, we have considered how the two systems interact, how the research points to an integration of episodic and semantic knowledge during the normal course of comprehension. To bring this chapter to a close, we'll begin with a short section on the validity of the distinction between episodic and semantic memory. Then, the "featured attraction" of the final section will be presented, Anderson's (1983) model of human memory called ACT*.

This model, probably more than any other in cognitive psychology, has ambitions to explain the entirety of normal human mental activity, including the important, but for the most part recently ignored, topic of learning. Given that all information in memory has to have been learned at some point, in some fashion or another, the ACT* focus on learning is a particularly important feature.

\[ \text{The Semantic-Episodic Distinction} \]

Let's begin with the basic distinction between episodic and semantic memories that we cited in chapter 5. Episodic memory is autobiographical, personally experienced memory, and semantic memory is generalized, world knowledge memory. It was obviously useful for cognitive psychology that Tulving (1972) enunciated this distinction—an avalanche of research was generated by the 1972 paper, research that established many productive pathways for the investigation of cognitive processes. Indeed, it's almost as if cognitive psychology had been waiting for one of its most respected practitioners to say "It's OK to study what people already know."

At a general level, it's clear that there is a distinction to be made. We noted, for instance, that episodic tasks require the subjects to be exposed to some specific input during the experimental session, and then to report back in some fashion what they remember from the input. In contrast, "pure" semantic tasks merely test people on the knowledge they bring with them to the laboratory, assuming that all the subjects have at some earlier stage acquired the information that will be tested.

And yet, as the present chapter has shown, it is an oversimplification to believe that these two kinds of memory are truly separate. After all, the research you've studied in this chapter presents specific input to the subjects in episodic style, yet found that memory for that input was strongly influenced by what the subjects already knew. Are semantic and episodic memories different after all, if it's so easy to find meaning-based influences in an otherwise episodic task? Is there merit in the distinction, beyond a kind of crude categorization of laboratory tasks? Should we think of them as the two end points on a continuum, with some research tapping processes more toward one end of the continuum, some toward the other end? (Notice that from a hypothesis-testing standpoint, it will always be easier to claim that they are different than to claim they are not different.)

A rather extensive literature on the semantic/episodic distinction has appeared in the past decade, proposing different tests of the distinctions, and different answers to the question. One particularly important strategy for conducting such research is to assume that if there is a true distinction, then there should be some experimental tasks that show episodic influences but not semantic influences, other tasks that show the reverse, and still others that show influences from both kinds of memory. For example, Shoben, Wescourt, and Smith (1978) found semantic relatedness effects in a sentence verification task—RT was speeded up to related sentences such as "Tiger has stripes" versus "Tiger has ears." In a different condition, they asked subjects to study the whole set of sentences, then make yes/no decisions as to whether test sentences were the same as, or different from those in the study set. In this more episodic task, they found no effect of semantic relatedness, but instead found a more episodic result, termed the fan effect.

\[ \text{The Fan Effect} \]

Basically, the fan effect means that performance will slow down on any fact if that fact is but one of many that have been learned about a particular concept. As Anderson (1976) found, if you learn three facts about "the policeman" (that he lost his pencil, that he bought a newspaper, and that he cashed a check), then it takes you longer to decide that any one of those statements is "true," compared to deciding about a concept that was only associated with one fact ("the banker ate a hot dog"). Since subjects in this kind of experiment must first study the list of sentences and then be tested on them, the typical "fan" experiment seems to qualify as an episodic task.

Anderson (1974, 1976; also King & Anderson, 1976) generally viewed such research as being more semantic, however, since comprehension of the sentences presumably involves constructing a propositional, meaning-
based representation. A rather problematic issue is raised by Anderson's view, however. If the typical fan experiment is testing semantic representations and processes, and if the obtained fan effect is generally true of semantic memory, then there is a disturbing implication. Stated simply, the more you learn about some topic or concept, the harder it should be for you to retrieve any particular piece of information about it. This implication certainly defies common sense—it suggests that a genuine expert on some topic should take much longer to remember any piece of that expertise than a relative novice.

Recent research seems to have cleared up this paradox, and in the process has shed some new light on the semantic-episodic distinction. Experiments by Myers, O'Brien, Balota, and Toyofuku (1984) have shown typical fan effects for stimulus sentences such as those used by Anderson (1976), but then have shown that the fan effects go away when the sentences can be integrated into a more cohesive structure. For instance, one of Myers et al.'s stimulus sets started with: "The banker decided to see a baseball game," followed by "arrived at the ball park." Subjects then saw either a high-integrated phrase, "and found a crowd buying tickets," or a low-integrated phrase, "and bought a souvenir penant." The high-integrated phrases were designed to be reasonable actions that were "enabled or caused by the actions of the preceding sentence" (p. 220). With high-integrated sentences, no fan effect was obtained. In other words, it appears that the fan effect may only be true when the facts being tested are rather arbitrary, unordered, and unrelated in a cause-effect way (see also Smith, Adams, & Schorr, 1978; Myers et al. also suggest that Anderson's experimenter-paced presentation of the stimulus sentences leads to relatively weak memory, and therefore prominent fan effects; see chapter 5, footnote 5). If the various propositions that we learn are well integrated and cohesive, the fan effect vanishes, and the results resemble the typical semantic memory results more closely. Indeed, Salasoo, Shiffrin, and Feustel (1985) have recently found semantic-like retrieval with purely episodic material—nonwords like MANTY were used—under conditions in which the nonwords were tested repeatedly. Apparently, what begins as a weak episodic trace will eventually, with sufficient practice and repetition, become very semantic-like in its speed and accuracy of retrieval.

The more general implication of such results is that the contents of semantic memory, aside from other differences, have been highly interrelated, practiced, and overlearned, and are stored in a highly accessible fashion as a consequence. This is conceptually similar to Bahrick et al.'s (1975) notions about extended overlearning of one's high school classmates, and the resulting memory record that endures for very long periods of time. While it is not entirely clear that all of the claimed differences between episodic and semantic memory can be attributed to differences in the degree of learning and interrelatedness, it is certainly tempting to assume that these factors may account for many of them. Somehow I'm sure Ebbinghaus would be amused that cognitive psychology, for all its advances, lost sight of such a fundamental variable.

Are They Different? As for the original question, "Are they different or not?" we'll have to be content with a partial answer. On the one hand, semantic representations serve the top-down function of providing context and related information as we comprehend written or spoken discourse, and of course provide the basic "definitions" of concepts we encounter in everyday experience. Clearly, then, episodic interactions with the world require a semantically rich system to supply meaning to experience.

On the other hand, the pattern of influence from episodic to semantic memory is somewhat more clouded. To be sure, much of what is stored in semantic memory got there by an episodic route—this is in fact a strong claim made by Shank and Abelson (1977) concerning scripts. And Salasoo et al.'s research tends to suggest that an episodic memory can become "semantic-like" in its retrieval characteristics if subjected to enough practice and overlearning. Yet, it is not true that all the information coded in semantic memory was once episodic, with the episodic eventually migrating as it becomes more overlearned. Inferences, for instance, are a class of facts that are coded in the semantic system, but need never have been learned in the technical sense (Aristotle's hands). Whereas semantic memory seems to lend itself to such processes as inference and generalization, especially when viewed in terms of script processing, it almost seems a contradiction in terms to speak of "episodic inferences and generalizations."

We have perhaps reached the point at which the basic distinction has little power to explain more complex, interactive effects. At simpler levels, it is useful to refer to episodic and semantic memories as separate classes or categories of knowledge. Furthermore, the distinction certainly serves a tremendous organizing function, as evidenced by chapters 5 and 6. But in the face of the "integrating" research you've read in this chapter, the question is becoming as unilluminating as any of psychology's other "either/or" puzzles ("Is it nature, or is it nurture?" springs to mind as the ultimate example here). Yes, we have memory for personal experiences, an episodic-based system, and yes, we have memory for general world knowledge, a semantic-based system. More importantly, however, the two systems are in continual interaction, each assisting the other, each coexisting with the other in a unified human long-term memory.  

ACT*

Since 1976, John Anderson has written extensively on a model, or series of models, known as ACT; the acronym stands for "Adaptive Control of Thought." His most recent version of this model or framework, ACT* (pronounced Act-star), was described in the 1985 book The Architecture of Cognition. We will not be concerned here with the modifications and

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12The debate on whether there is or isn't a distinction between episodic and semantic memory is heating up again. See McCown & Ratcliff (1986) for an argument against the distinction.
amendments that have been necessary across the several versions of the model. Instead, we want to describe the ACT* model and its explanation of cognitive processes at a level that will illustrate its generality, some of its principle mechanisms, and some of its theoretical ideas.

While some have voiced the opinion that Anderson's ACT* is the most significant, large-scale model to have emerged from cognitive psychology, Anderson's view is somewhat more modest: "We call it ACT* to reflect the belief that it is the final major reformulation within the ACT framework.... [This] implies that I expect ACT* to be wrong. This expectation is based not on any weaknesses in the theory, but on the nature of progress in science, which comes from formulating theories that account for a wide range of known phenomena and then finding out what is wrong with these theories.... In its present stage of maturity the theory can be broadly applied, and such broad application has a good chance of uncovering fundamental flaws" (1983, pp. 18–19).

The theory is considerably too young to have been subjected to the careful research that might reveal some of those fundamental flaws. For that matter, it is considerably too complex to be tested directly with one "definitive experiment." Anderson states that empirical tests will need to develop specific ACT*-derived models, testing those as subordinate components of the overall ACT* framework. Therefore, our interest in the model is based more on a demonstration criterion: ACT* seems to have the capacity to accommodate all of the areas we've discussed since chapter 5, and several more that are covered in later chapters. Sometimes, this explanation is only in generalities, but sometimes it involves great detail. Further, ACT* is a broad framework that addresses not only the verbal-based knowledge we've focused on, but also imaginal and other nonverbal knowledge. Its very scope, and the fact that empirical results have played a large role in shaping the current model, suggest that cognitive psychology has indeed made progress in achieving a unified, general understanding of memory and its operation.

**The Structure of ACT*** Let's begin with familiar notions, seeing how they are embedded within ACT* before we progress to the new ideas in the model. Figure 7–14 shows an overall representation of the ACT* architecture, the overall structure of the memory system according to Anderson.

First, you'll notice a familiar term, working memory. For now, understand that component in its usual sense, the mental "scratch pad" that keeps track, holds intermediate outcomes, and so forth (we'll revise this conception later on). In the model, various encoding processes serve to bring information from the outside world into working memory; these include the sensory memory processes we discussed in chapter 3, along with the attentional mechanisms that transfer sensory memory information into short-term, working memory. And, as was characteristic of even the first serious information processing model (Atkinson & Shiffrin, 1968),

[Diagram: The architecture of Anderson’s (1983) ACT* model, showing the major components and the processes that occur within the system.]

externalized behavior that results from cognitive processing is also controlled most directly by working memory.

The next major component is declarative memory, a term introduced in chapter 2 in the discussion of the "representation of knowledge" theme. In Anderson's usage, declarative memory includes both semantic and episodic knowledge, as we have used the terms here. Based on Anderson's (1976; Anderson & Ross, 1980) long-standing view that there is no inherent distinction between these two, it is not surprising that both are combined into the single declarative memory structure (note that the distinction between type and token nodes is critical here, in order to keep straight a general concept such as DOG—the type node—and a particular "episodic" instance of the category such as Larry's dog—the token node). Furthermore, given this view, it is not surprising that both kinds of knowledge are highly interrelated, and are operated on by the same laws of memory (laws concerning strength in storage, formation of associations, and probability of retrieval, to name just three).

As we concluded in chapter 6, the best hypothesis about the structure of semantic knowledge is that it is stored as an interrelated network of nodes, connected by linking pathways, and accessed by means of spreading activation. All of these aspects are also true of Anderson's declarative
memory. ACT* stores a broader range of information than just abstract, semantic nodes, however. Anderson (now) claims that, in fact, there are three distinct kinds of knowledge codes, three types of representations that are contained in declarative memory. One is the familiar abstract propositional representation, especially useful for verbal and other symbolic concepts and relationships. The second type is a temporal string, a representation that codes the order of a set of items, events, etc. And the third type is a spatial image, which codes the spatial configuration of a stimulus pattern or event (including visual images, of course). As the arrows in Figure 7-14 indicate, new information is stored in declarative memory by the actions of the working memory component. Likewise, when knowledge is retrieved from declarative memory, a copy of the representation is placed into working memory—in other words, that information is now activated and ready to be processed.

Production memory is the third and most important component of the ACT* architecture. This third memory component is a new kind of long-term memory, one we haven’t encountered before. It is the component that distinguishes ACT* as a genuinely different theory from, say, the Collins and Quillian network model or the Schank and Abelson schema/script theory. Production memory is closely related to the term procedural knowledge (Anderson, 1976, 1982), which means knowledge of how to do things. For example, knowledge of how to ride a bicycle is procedural knowledge, as is knowledge of how to drive a car, how to bake a cake, and how to carry in addition and borrow in subtraction. All of these kinds of knowledge are part of production memory, along with other “how to” kinds of information. According to Anderson, the difference between procedural and declarative knowledge is the difference between “knowing how” and “knowing that.” Thus, production memory is the long-term memory store for procedures, for procedural knowledge.

In ACT*, the distinction between procedural and declarative knowledge is of fundamental importance. One illustration that proves they are indeed different is the ease with which we can verbalize our declaratively-stored knowledge (a robin has wings), in contrast to the awkwardness with which we describe our procedural knowledge. Try to give an accurate verbal description of tying shoelaces or a necktie, to illustrate how fluent procedural knowledge fails to translate into clear, precise verbal expression. Another example, one we’ll develop in the next chapter, involves language, specifically, our easily verbalized word knowledge, but difficult-to-verbalize knowledge of the rules for putting words together into coherent sentences.

The reason this component is called production memory is because of a basic assumption embedded into ACT* about how things happen in cognition. ACT* is a computer-based model, existing as several, separate computer simulations and artificial intelligence programs designed around the notion of production systems. A production system is a set or system of productions, to be circular about it. Well, what’s a production, then? A production is the basic building block of dynamic cognition, the units out of which thought is composed. More technically, a production is an IF-THEN pair of elements or clauses, where the IF part specifies a certain condition, and the THEN part specifies a certain action. Schematically, a production says IF Condition X is true, THEN take Action Y; IF a glass of liquid is raised to your lips, THEN tilt the glass and drink. Actions need not be physical movements, however. They can also be mental actions, or even relationships among concepts. For instance, a simple production that states a semantic, propositional relationship is: IF person 1 is the father of person 2, THEN person 2 is the son of person 1. Likewise, a slightly more complex production would be:

“IF person 1 is the father of person 2, and person 2 is the father of person 3, THEN person 1 is the grandfather of person 3” (Anderson, 1983, p. 6).

In Anderson’s words, “Underlying human cognition is a set of condition-action pairs called productions. The condition specifies some data patterns, and if elements matching these patterns are in working memory, then the production can apply” (1983, p. 5). When the production applies, then the action part is executed. Sometimes this results in observable, external behavior, such as drinking the liquid in a glass; sometimes it results in some internal mental activity, such as searching for some new fact in declarative memory. It always results in adding a new element to working memory, essentially the record that the action has been taken. This addition to working memory is the way that the system keeps track of what it’s already done, and what remains to be completed in some task or mental operation. Thus, a production, in its simplest form, is a pair of IF-THEN clauses, where the first part specifies some set of conditions that must be met in order for the actions described in the THEN part to be taken. When a production is applied (or, in the jargon of production systems, “when a production fires”), a record of its action is placed in working memory to update the “state” or current condition of the system.

Productions can be very simple, as the above examples were, or more complex—more than one condition can be specified in the IF clause, and more than one action can be specified in the THEN clause. Regardless of their complexity, however, they are all stored in production memory. Note that even for relatively simple cognitive acts, there would be many relevant productions. In his sample production system for performing addition, Anderson (1982) lists 12 separate productions, and even this set requires that the simple addition facts such as 2 + 3 and 4 + 9 be stored in declarative memory. When viewed in this light, the cognitive theorist’s job is to specify all of the productions that are necessary to accomplish some mental activity or behavior. Given the size of this task, even for simple mental acts, it becomes clear how modern computer technology has infiltrated, and become indispensable to, the world of cognitive theory. As mentioned, Anderson’s ACT* is programmed as a computer simulation. Thus, Anderson is theorizing about mental activity by programming a
computer with productions, then testing the program to see if it performs the way people do, errors and all.

**Processing in ACT** As illustrated in Figure 7-14, working memory accesses production memory through a matching process. Consider a situation in which conditions A, B, C, and D are true—all four of those conditions or states are currently in working memory. Now, production memory will have, among its myriad productions, some group of productions that are relevant to the task being performed; in other words, production memory will have a group of productions whose IF clauses mention some of the relevant conditions A through D. Imagine that production #25 (the numbers are arbitrary, of course) says “IF A and B and C, THEN do X,” also imagine another production, #28, which says, “IF A and B and C and D, THEN do Y.” It should be clear from this simple example that production #28 will be the production to “fire” or act next, since the overall state or situation in working memory matches #28’s conditions more closely than #25’s (or any other production’s conditions). As a consequence, when #28 fires, its action clause—do Y—is executed or performed. The result of this execution is that a physical or mental action may be taken, and a record of Y will be deposited in working memory (see Anderson, 1982, 1983, for details).

Secondly, the additional loop in Figure 7-14, labeled application, is a mechanism by which new productions are learned and existing productions are modified (note that this is different from the simpler term “apply” as used in the phrase “when a production is applied”). The system monitors its own performance, and acquires and modifies productions as a consequence of its successes and failures (one wonders if this is metamemory). If firing a production in a particular circumstance leads to errors, then feedback on those errors can be incorporated as modifications to the production. For example, a second grader might give the answer 12 to the problem 42 — 3, showing evidence that one or more productions in the child’s subtraction knowledge are faulty (e.g., since you can’t take 3 from 2, write down the 2, then take 3 from 2; see the description of this research by Brown & Burton, 1978, in chapter 13). Via feedback, the error in the child’s procedural knowledge will be corrected, in this case by elaborating procedural knowledge to include the procedure of borrowing. In a very real sense, ACT learns productions by ‘doing,” and then by correcting and doing again.

Finally when sets of productions are used repeatedly to perform the same actions, they can be grouped or “chunked” together in a general process called composition. Through this mechanism, what was once a series of separate productions becomes a single, unitized production. A straightforward example of this would be tying your shoes. What began as a series of discrete steps (in sequence, the THEN clauses would be something like “hold a lace in each hand, cross them and switch hands, loop one lace through the opening,” etc.) eventually becomes a composed production, a single production with the THEN clause, “tie the laces.”

The entire process by which knowledge shifts from a generalized, interpretive process to a more task-specific and task-relevant process is called knowledge compilation: “According to ACT*, all knowledge initially comes in declarative form and must be interpreted by general procedures. However, by performing a task, proceduralization gradually replaces the interpretive application with productions that perform the behavior directly...Proceduralization and composition, which together are called knowledge compilation, create task-specific productions through practice” (p. 34). In this fashion then, ACT* not only learns, but eventually shows a pattern we have encountered repeatedly—automatic processing (e.g., Shiffrin & Schneider, 1977), one of our seven themes in cognition. As separate productions merge into one “superproduction,” the separate actions merge into an inseparable chain or sequence (see Hayes-Roth, 1977, for a compatible notion). The sequence is now triggered as a unit, and is performed automatically. Since actions can be either overt, behavioral responses or internal, mental operations, it is clear that ACT* has the capacity to explain automaticity, as well as the progression of a mental operation from a relatively conscious to a more automatic level.

**Empirical Applications of ACT** As stated, ACT* is too new a theory to have been tested to any useful degree (some feel it can never be adequately tested, and as a consequence is not an empirical model at all). Indeed, with a model as complex as ACT*, which exists principally as a computer simulation, it can be close to impossible for anyone other than the model’s creator to test it directly, since only its creator has access to the original computer programs. This is not to detract from the argument that computer simulation is an excellent way of developing cognitive theory, but merely to admit that theorizing in this fashion has its own set of strengths and weaknesses (for further discussion of this, see chapter 13; also Ashcraft, 1987; Loftus, 1985). We will content ourselves here with a brief description of the empirical tests that Anderson (1983) cites as being consistent with the predictions and performance of ACT*.

An important detail of ACT*, not yet mentioned, is that each node of information in declarative memory is stored in the network with a specific strength value. Strength values are a function of a variety of input var-
ables, such as number of presentations, degree of rehearsal and elaboration, and frequency and recency of usage. Based on these functions, ACT* predicts virtually the entire range of episodic effects we discussed in chapter 5—the model predicts practice effects, encoding specificity effects, and even traditional paired-associate learning effects. Anderson has made the explicit assumption in ACT* that so-called forgetting is a failure of retrieval; that is, if some element was encoded into declarative memory, then “forgetting” of that element is due to retrieval failure. This is, of course, the encoding specificity hypothesis we discussed in chapter 5, and the related notions of availability versus accessibility of stored information.

Beyond such episodic effects, ACT* also predicts the standard semantic memory effects we covered in chapter 6. Because nodes are encoded into a network structure, the resulting structure illustrates the semantic relatedness and typicality dimensions we discussed in the last chapter. (Anderson refers to this as a “tangled network structure,” since nominally episodic and semantic nodes are freely intermixed. Nonetheless, processing is the same for both kinds of nodes.) Since retrieval in ACT* is a process of spreading activation through the strength-dimensioned structure, the traditional RT results are predicted by the model. Likewise, priming effects and even prototype formation are predicted by the model (Anderson, 1983, pp. 96–105, p. 254, respectively), even to the extent that priming of ambiguous words is discussed.

On the other hand, ACT* is still committed to the fan effect. Even with extensive practice on a set of stimuli, the model predicts that the fan effect will remain (Figure 5.2, p. 183). From the description, it is not at all clear that this prediction, and the data that support it, take into consideration the “high vs. low integration” factor identified by Myers et al. (1984; but see Anderson & Reder, 1987, on sensitivity judgments and the fan effect). It would be a shame for empirical tests of ACT* to fixate on the fan effect to the exclusion of other aspects of the model, but it may well be that this will be the empirical battleground for most ACT* tests. Alternately, there may be sufficient elasticity in the model that high vs. low integration will translate into differentially strengthened pathways between nodes, in which case ACT* might not be defeated on that battleground. But then, of course, people will complain that the model is so flexible that it makes no definite predictions whatsoever.

Finally, it must be admitted that ACT* truly comes into its own, in a manner of speaking, when more conscious, deliberate mental processes are involved. Much of the flavor of the model seems peculiar when relatively automatic, low-level processing is involved. For instance, in the productions for addition, there is a continual repetition in the IF clauses of “goal” and “subgoal.” “IF the goal is to iterate through the columns of an addition problem...THEN the subgoal is to...” (Anderson, 1982, p. 8).

It’s now intermission (aka midterms). You’ve come halfway through the book and essentially halfway through cognitive psychology. My feeling is that the first half of the book forms the real core of cognitive psychology, presenting topics that are almost universally viewed as central to an understanding of the field. The remainder of the book consists of topics that are at least somewhat more independent of one another (although highly dependent on the core you’ve already mastered). For example, the next three chapters concern aspects of language that are important to cognitive psychology, or at least aspects that some cognitive psychologists have studied. Some may view these as slightly tangential to the main thrust of cognitive psychology; others may find in them a needed elaboration and extension of principles and issues that have come before (e.g., automaticity, representation of knowledge). Likewise, neurocognition, as I have termed it, is a rapidly developing subfield, with great potential for filling in some of the gaps in cognitive psychology. Some may feel that the potential is so far from being realized that the entire topic is better left for the future; others view this as a critical test case for cognitive theories, so are willing to cope with the field’s incompleteness (still others are reassured that, so far, no definitive findings in neurocognition have contradicted our conclusions in mainstream cognitive psychology to any fundamental degree).

The course you’re taking now will probably have covered most of chapters 1 through 7; you may not be covering all of the remaining chapters, at least to the same depth. As I always tell my own students, however, just because it’s not assigned doesn’t mean you can’t read a chapter; after all, you bought the book.

**CHAPTER SUMMARY**

1. Bartlett’s (1932) early research demonstrated an important fact that motivates the topic “integrating semantic and episodic memory.” When meaningful material is to be remembered, we tend to reconstruct the memory from two sources, the presented information and our existing knowledge. Bartlett used the term *schema* to refer to this existing knowledge base, and found that the subjects’ schemata led to various omissions, distortions, and alterations of the originally-presented material.

2. Research on simulated eyewitness testimony, as well as more straightforward work on semantic integration, suggests that new infor-
3. Comprehending a sentence involves constructing a propositional representation, in which the meaningful elements are represented as nodes connected by various pathways (e.g., agent, recipient, etc.). Considerable evidence has been reported in support of this notion; we tend to remember the gist or general meaning of a passage, rather than superficial aspects, and we routinely “recognize” a sentence as having occurred before even if the sentence is a paraphrase. Such technical inaccuracies are, in fact, evidence of what is termed content accuracy, correct recognition or recall based on the meaningful content of the to-be-remembered material. Propositions form the base of several important lines of research, including studies of semantic memory performance, recall of connected prose, and comprehension and recall of stories.

4. Scripts are large-scale representations of complex events and episodes, such as going to a restaurant or attending a birthday party. Script knowledge can be represented in the same kind of network structure as propositions, and is assumed to be accessed by similar processes, e.g., spreading activation. A story invokes a script by mentioning so-called headers, and these in turn activate the entire script. Script theories make a variety of predictions about comprehension and retrieval, and provide a useful way of explaining how people understand and interact with the real world.

5. Despite the important organizing function of the distinction between episodic and semantic memory, the research does not permit a clear answer to the question “Are they different?” While this debate has not yet been resolved, it is important to bear in mind the important point that—separate or not—semantic and episodic memories are continually interacting systems of knowledge. Everyday experiences are understood by means of semantic concepts and connections, a confirmation of the pervasiveness of this kind of conceptually-driven processing in normal cognition.

6. Anderson’s ACT* model is composed of three basic memory components, working memory, declarative memory, and production memory. His model is based on productions, IF-THEN statements that specify what kind of action—whether physical or mental—should be taken under what conditions. By means of various mechanisms, production memory in ACT* acquires new productions and modifies old ones, eventually “collapsing” several productions that occur sequentially into a single, unitized production. While the model is too new to have been tested thoroughly, it appears to be the most general theory of cognitive processing in the field, addressing issues all the way from short-term memory performance up through problem solving.

SUGGESTED READINGS

As was mentioned, one of the current “battles” in cognitive psychology is the eyewitness testimony area and its implications for the permanence and/or immutability of memory traces. Loftus’s (1979) book explores the testimony issues thoroughly; her 1980 book and the Loftus and Loftus (1980) American Psychologist article discuss the more global issue of permanence in memory. On the other side of the debate, that the evidence does not support a “memory impairment” or alteration interpretation, see McCloskey and Zaragoza (1985; also Zaragoza, McCloskey, & Jamis, 1987). In response, Loftus and her colleagues have reported on the difference between perceived and “unreal” memories, i.e., memory for an event that was perceived vs. one that was suggested to have occurred (Schooler, Gerhard, & Loftus, 1986). Bekerian and Bowers (1983) have provided a useful discussion entitled “Eyewitness testimony: Were we misled?” Concerning the issues of expert testimony on the part of cognitive psychologists, see the papers by McCloskey and Egret (1983a and b) and the rebuttals by Loftus (1983a, b).

Script and schema theories, along with propositional approaches to discourse processing, are the subjects of a good many research projects, and are being applied to a large variety of comprehension situations. See Schank’s (1972) basic paper on “conceptual dependency” as a challenging, but essential introduction to his approach, Schank and Abelson (1977) as a very readable guide to the scope of the project, and Abelson’s (1981) paper on the diversity of topics that can be accomodated within script/schema theory. One of the cleverest applications surfaced recently in Psychology Today, in a paper by Raskin (October, 1985)—a script explanation of jokes. As Raskin notes, the following joke invokes two different scripts, one per character: “Is the doctor in?” the patient asked in his bronchial whisper. ‘No,’ the doctor’s young and pretty wife whispered in reply. ‘Come right in.’” (p. 36).

Several recent papers discuss the distinction between episodic and semantic memory: see Dosher (1984); McCloskey & Santee (1981); McKoon, Ratcliff, & Dell (1985, 1986); Neely & Durgungolgu (1985); and Tulving (1986).

Finally, the topic of computer simulations of cognitive processes is an increasingly important one. To pursue this end of script theories, see the book by Schank and Riesbeck (1981), which not only explains the psychology of the approach, but also gives a miniature lesson in the premier simulation language, LISP. This is followed by five “miniature” programs that can be studied as functioning examples of comprehension theories (e.g., SAM, Schank and Abelson’s Script Applier Mechanism model, is described as Micro-SAM, alias Msam, a miniature that understands the “shopping in a store” script). To pursue the simulation approach in ACT*, read Anderson (1982, 1983).