8 The Role of Thematic Knowledge Structures in Reminding

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INTRODUCTION

Other chapters in this book have discussed types of knowledge structures such as scripts and MOPs. These structures serve to organize related experiences based upon their similarities; for example, restaurants that share the features of fast-food establishments could be organized under the *fast-food restaurant* script in memory, which would provide the appropriate expectations for that situation. Another kind of similarity between episodes, *themes,* involves a more abstract level of information. For example, consider the many types of knowledge applicable to this story:

> Nixon had struggled hard to beat J. F. Kennedy, but his efforts were not able to win him the election. When his supporters finally accepted the inevitable defeat, there were more than a few tears and hollow hopes for 1968. After successfully challenging Humphrey in 1968, Nixon was finally inaugurated.

In this story, knowledge could be accessed from a variety of concepts, such as Nixon, politics, elections, failed attempts, and optimism. Some of these (e.g., Nixon) are highly specific, while others (optimism) are very general. The most general thematic characterization of Nixon's situation, "if at first you don't succeed, try, try again," is useful information in many settings other than politics. Unlike the *fast-food* information, the theme in this story could serve as a generalized structure in memory that is not dependent on accessing its context, that is, Nixon's election. This abstract thematic information could be organized in memory as more general,

high-level schemas so that episodes from a variety of contexts were stored together in memory based on their thematic similarity. Generalized thematic knowledge structures may be needed to understand and encode new episodes, and to recall the thematic information when it is appropriate.

THEMATIC MEMORY STRUCTURES

The Thematic Level of Knowledge

What kind of structures capture the thematic similarity between episodes? Knowledge about the world can be characterized as ranging from completely context-dependent to very abstract. Some of our knowledge of the world can be captured by explicit propositions about the circumstances of an episode; however, other knowledge depends on the relationships between explicit concepts. Typically, *schemas* are proposed to represent knowledge of familiar events as relationships among concepts. The information in a schema is usually assumed to be organized into a structure, reflecting, for example, temporal contiguity, importance, or more abstract relations, such as that between a goal and a plan for its attainment. The content of the schema and its structure define the inferences that can be made when the schema is activated in memory. Some schemas organize information in a very specific context, such as a restaurant, while others represent much more abstract knowledge such as the role of authority or ways to avoid problems in life.

The use of schemas in remembering textual information has been well documented. In early work, Bransford and Johnson (1972, 1973) and Dooling and Lachman (1971; also Dooling & Mullet, 1973) demonstrated that ambiguous stories were easy to understand and recall if they were given a title that referred to appropriate background knowledge but very difficult without the title. Similarly, experts, who can provide extensive background knowledge for themselves, do better at recalling information in their area than nonexperts (Chiesi, Spilich, & Voss, 1979). Schemas have been shown to determine not only how much of a text will be recalled but which parts of a text will be recalled. If a schema is mentioned at the time a text is read, information relevant to the schema is more likely to be recalled (Pichert & Anderson, 1977) and more likely to be recognized (Graesser, Woll, Kowalski, & Smith, 1980; Schallert, 1976). Schema-relevant information is also more likely to appear as intrusions in recall protocols than schema-irrelevant information (Bower, Black, & Turner, 1979). Finally, facts that can be organized by well-known schemas seem to be more tightly connected in memory than facts that cannot be so organized (McKoon & Ratcliff, 1980a).

All of this work (and much more, see Alba & Hasher, 1983, and Taylor & Crocker, 1981, for reviews) provides the necessary background to document the importance of the notion of schemas and to lay the foundation for further research. The particular directions that we investigate in this chapter involve consideration of an abstract type of schema and the kinds of processing in which such schemas might be involved.

Thematic knowledge structures capture this level of similarity by representing the patterns of goals and plans in the episode. The theme, or point, of an episode lies in more abstract relations between concepts. This higher-level, thematic information is often independent of most contextual features. For example, the thematic information involved in the notion of "retaliation" is not dependent on a particular context; one can imagine retaliation occurring in a wide variety of settings. A terrorist group retaliating against a government crackdown with a bombing incident is quite different in context from a child, feeling wronged, tattling on a sibling. The actor information in a representation of the "retaliation" theme has to match both a desert-trained commando and a self-righteous four-year-old; they have little in common on the surface. What they do share is the pattern of the actor being harmed, giving rise to his goal of revenge. So, although quite different in many ways, every episode that embodies the theme of "retaliation" is, at a more abstract level, equivalent.

These patterns could be used to recognize the meaning of an episode, and to organize in memory episodes that share the abstract similarities represented by the pattern. Because the structures are built from experiences, they represent generalizations made across episodes that vary greatly in some respects while sharing more abstract similarities. Schank (1982) outlined a class of thematic structures whose purpose is to characterize complex interactions of goals and plans. "Thematic Organization Points" (*TOP*s) represent the problems occurring during the pursuit of a goal and the issues relating to what happens after a goal succeeds or fails. Because the thematic vocabulary is sufficiently abstract, *TOP*s are useful in recognizing and remembering episodes across domains. TOPs are related to earlier versions of "themes" (Abelson, 1973; Schank & Abelson, 1977), and differ from other structures proposed to capture thematic information (e.g., Lehnert, 1981; Wilensky, 1983) in the emphasis on the overall pattern of goal and plan interaction, the importance of the attached conditions, and their functionality as structures in memory. As a characterization of a particular pattern of goal and plan interactions, *TOP*s as memory structures provide convenient organizations of episodes.

Consider this example from Schank (1982):

> X was talking about how there was no marijuana around for a month or two. Then, all of a sudden, everyone was able to get as much as they wanted. But

the price had gone up 25 percent. This reminded X of the oil situation the previous year. We were made to wait on lines because of a shortage that cleared up as soon as the price had risen a significant amount.

The *TOP* Schank proposed as the structure of this episode can be labeled "Possession Goal; Commodity Mysteriously Unavailable." This organization point in memory is based upon the significant conditions that affect the planning for the possession goal. Other pieces of information needed in this case would be "becomes available later," "higher price," and perhaps "controlled by unethical people." The conclusion contained in this structure is that unethical people who control a commodity will put it back on the market once the price has risen. The *TOP* also provides planning information, namely that the goods will be available later at a higher price, so one should wait a while and prepare for the future purchase. In this way, matching a new situation to a thematic structure can help in understanding and may suggest a way of solving a problem. In the commodities example, the structure provides the assurance that the commodity will be back on the market soon, but with a higher price.

Schank (1982) uses the functionality of the structure in memory to constrain the representation of the thematic information. *TOP*s as knowledge structures are based on the principle of functional constraints on memory; that is, the form and content of *TOP*s depends on their use. *TOP*s should contain the right information and be organized in a particular way in order to provide appropriate knowledge when needed. Knowledge structures perform several functions: for example, they may aid in recognizing an old story in new trappings, provide expectations about the situation, and predict an outcome for a newly encountered situation. In addition, *TOP*s provide the concise "point" to a story (such as an adage,) and let you guess how something will turn out because you have seen the steps before. The *cross-contextual* nature of *TOP*s makes them of particular interest for learning information in one situation that will apply in another. For example, *TOP*s may bring to mind a story that illustrates a point, thereby providing an explanation of co-occurrences of seemingly unrelated events in order to draw conclusions. One very important function of *TOP*s is to aid in learning about the world from varying contexts.

How can we determine what *TOP*s might exist in memory? It's not as easy as listing the different kinds of common scripts we know about. First of all, since they are based on experiences, the *TOP* structures formed by any individual will be highly idiosyncratic. Second, there exist endless variations of goal and plan interaction patterns: which ones are distinctive and useful in memory organization? Because knowledge structures are based upon common episodes in the world, examining similarities in experiences may uncover some *TOP*s used to organize those experiences. Schank

(1982) has suggested examining the similarities and themes in everyday life that are revealed in common adages and sayings. Adages are patterns of goal and plan interactions that people recognize and share, and that remind people of other experiences. A moral derived from a story is the realization of the point of the story, and so can serve as an effective way of characterizing the theme of an individual episode. It would seem that cultural sayings, based on the commonalities of experiences in a variety of settings, are a good place to begin looking for thematic structures to organize episodes in memory.

Thematic Abstraction Units as Knowledge Structures

Dyer (1983) has used this approach to develop Thematic Abstraction Units (*TAU*s). *TAU*s are based on patterns of goals and plans seen in common adages—in particular, adages that represent expectation failures due to errors in planning. *TAU*s are thus a subclass of *TOP*s. A *TAU* contains an abstracted planning structure that tells where the error in planning occurred, that is, where something that was expected to happen did not. *TAU* structures are important both within a story and as a connection between stories, as they represent the thematic structure of a single episode and serve as episodic memory structures which organize similar episodes. Consider this example story from Dyer (1983):

> In a lengthy interview, Reverend X severely criticized the then President Carter for having "denigrated the office of president" and "legitimized pornography" by agreeing to be interviewed in *Playboy* magazine. The interview with Reverend X appeared in *Penthouse* magazine.

This is a routine news report of a clergyman complaining about pornography. However, because the story demonstrates the minister's involvement in the very activity he condemns, the point or moral of the story is the minister's hypocrisy. A *TAU* captures this point of the story, expressed by the adages *The pot calling the kettle black, Practice what you preach,* and *Don't throw stones when you live in a glass house.* Here is a *TAU* structure for the hypocritical minister's complaint (Dyer, 1983):

TAU HYPOCRISY:

X is counter-planning against Y
X is trying to get a higher authority Z to block or punish Y for using Plan P1 by claiming P1 is unethical
X has also used the unethical plan P1
therefore, X's strategy fails.

In the story, the minister tries to move public opinion against Carter by claiming Carter supports pornography. Since the minister supported it to the same degree, his strategy fails.

In this manner, *TAU*s serve to capture goal and plan interactions involving particular planning failures. These structures explain the pattern of goal and plan elements within the story, and serve as the basis for connections between related episodes. For example, the same *TAU HYPOCRISY* structure captures the minister's complaint story and the following story:

> Karen's swimming coach was a real slave driver. An athlete himself, he had the team working out for many hours every day. Besides their workouts, he insisted that each player be in great shape for the season. During the preseason training sessions, the coach would warn the players that they should avoid drinking, drugs, overeating, and especially smoking. "Everyone knows that athletes should treat their bodies with respect," the coach said as he puffed heavily on his long cigarette.

This *TAU* could have been very useful to the minister: if the minister had remembered and applied the coach story, he might have avoided making the same error of condemning someone when you may be caught doing the same activity. The *TAU* structure stores the planning information that denouncing someone's behavior will lose its effectiveness if you are caught doing the same thing. If the episodes can be organized in memory with the *TAU,* the important information about planning captured by the *TAU* can be available when needed.

Previous research has tested people's sensitivity to these *TAU* patterns (Seifert & Black, 1983). In that study, subjects were given three exemplars of a particular *TAU* pattern such as *TAU HYPOCRISY,* and were asked to write "one new story that has the same type of plot." Asking subjects to write stories based on prototypical stories should indicate whether they are able to abstract the thematic similarities in the prototypes and reproduce that theme in a new context. The three sample stories were "about" very different things, such as jobs or auto mechanics, but shared the same abstract pattern of making a planning error. The 56 subjects were given three sets of example stories and were asked to write three new stories. Eighty-two percent of the stories matched the *TAU,* using other contexts such as school, jobs, and dating to express the *TAU* pattern. In a second study, subjects were given lists of 36 stories, six each of six different *TAU* patterns (written by other subjects), and were asked to group the stories together, using any criteria they wished.

The results were analyzed using Johnson's hierarchical clustering algorithm (Johnson, 1967; Reiser, Black, & Lehnert, 1982), and showed that the stories were reliably sorted into six groups which corresponded to the six

*TAU*s the stories were based on. These results show that subjects are sensitive to the abstract, thematic structures, and further, that they can use these relationships to perform tasks based on similarities between stories. Subjects were able to preserve the *TAU* pattern in their stories so that it is recognizable to other subjects, and were able to use *TAU*s as the basis for story similarity. These experiments demonstrate subjects' sensitivity to thematic patterns, and indicate the thematic level of information can be used to compare and create stories. It also provides specific suggestions about what knowledge structures contain, for example, the analysis of clustering brought out the importance of *causation* in the thematic pattern. It is clear that the thematic information present in an episode plays a crucial role.

The thematic level of knowledge appears to be captured by structures that contain relatively abstract information about goal and plan relationships. This knowledge is clearly needed to understand the point of episodes based upon themes. Further, these structures may organize episodes that contain similar thematic information. The premise that thematic structures are useful in encoding and organizing related episodes suggests interesting properties of memory. If similar episodes are encoded using thematic structures, these structures may serve as the connection between related episodes. In order to find out more about the connections between episodes, we can look at their function in the phenomenon of *reminding*.

REMINDING BASED ON THEMATIC STRUCTURES

We can learn about *TOP*s by looking at reminding. Schank (1980, 1982) has proposed using reminding as a method to examine the role of knowledge structures and connections between episodes in memory. Reminding occurs when a particular situation causes one to remember another experience that is similar in some way. The relationship between the new input and the old memory retrieved can be at any level of abstraction or similarity. For example, seeing a bearded man in a red suit may remind you of Santa Claus, going into Burger King for the first time may remind you of McDonald's, and seeing "West Side Story" may remind you of "Romeo and Juliet."

The Mechanism of Reminding

Why does one experience remind us of another, especially when the two experiences share little apparent similarity of surface content? Schank (1982) proposes the theory that the second experience—the reminding—is a natural product of the attempt to understand the first. In this view,

understanding is a process that involves being reminded of the closest experience in memory to the input experience. Thus, Schank proposes that in understanding the new situation, you are led to structures in memory that categorize the input, and from there retrieve a previous episode which had been stored in the same way. Calling to mind previous episodes is even more likely if an interesting or unusual characteristic is present in the input. Schank's theory, then, is that reminding occurs as a natural part of the process of understanding new situations in terms of previously processed episodes.

Under this theory of memory, understanding an event means finding an appropriate place for a representation of that event in memory. Similar structures and episodes are searched through to find the closest related place in memory to store an input. Therefore, a reminding would indicate that a specific episode in memory has been seen or excited during the natural course of processing the input. To do this we must have been *looking* for the reminding or have *run into it accidently.* In either event, reminding occurs when we have found the most appropriate structure in memory that will help in processing a new input.

Imagine the following situation:

> You've been to McDonald's many, many times, but never to Burger King. The first time you go there, you're not sure what to expect. You walk in, stand in line, read the menu off the wall, order hamburgers and fries, put them on your tray, pay the cashier, and sit down to eat. Finally, you think, "You know, this place reminds me of McDonald's."

From your reminding, it is clear that you have understood Burger King in a sufficiently deep way. You understand Burger King in terms of McDonald's because they share many features. You go into Burger King, and you have to stand in line (just like in McDonald's). Then, you tell the cashier your order (again just like McDonald's). Then, you pay for your food before you sit down and eat it (McDonald's again!). Schank (1982) suggests that these two experiences share so many features that you cannot help remembering one when you first experience the other. Under Schank's theory, experiences that share so many features will also share a representational structure in memory. These shared features form the basis of a mental framework or knowledge structure in memory, and because the two restaurants share these features, both restaurants would be stored under the same structure in memory. If memory is indeed functioning based on the principle that the understanding process will involve accessing the closest related experience, understanding one restaurant experience will mean accessing the same structure in memory that the other shares. As a result of this process, people would be unable to

avoid thinking about related memories as they try to understand their experiences.

The Role of Cases in Understanding

Because we believe that it is not accidental that reminding occurs, it is important to consider the functionality of reminding. What is the function of retrieving another episode given a new one? Why would it be advantageous to be able to access a particular case in addition to the generalized structure? We have already seen that the *TOP* structure itself provides a lot of information such as expectations, explanations, categorization, and planning advice. From the structure alone, there is knowledge about making predictions for what is likely to happen, expectations about the problems one might encounter, and tips on the prevention of the same planning errors. While the structure serves many functions as outlined above, remindings must also serve important functions in understanding.

First, remindings may serve to evaluate the categorization of an episode by a *TOP.* When the *TOP* structure provides the generalization, the reminding can serve to evaluate how well the structure characterizes the new situation. With another case from the same memory structure, you can ask, "Are these two episodes really similar?" This can aid in recognizing when you've miscategorized an episode.

Second, because *TOP* structures are built from cases, the cases stored under a *TOP* serve as evidence for the generalizations it contains. At times, it may be useful to question the generalizations the *TOP* embodies: a frequent pattern may or may not be a good rule about the world. Being reminded of previous cases gives you an opportunity to say, "I've seen this pattern a lot—do I believe it?" Because you may discover correlations about the world without a full explanation of its causes, a mechanism to reevaluate the generalizations you form is very useful.

Third, specific cases are useful precisely because structures are generalizations. While the structure can provide general information, episodes can provide specific knowledge about contextual constraints. Some information, such as specific constraints on planning, is important only in some contexts. For example, a generalized rule such as *inform your coplanner of your plan* might be accessible from a *TOP,* but more specific advice to inform them in secrecy would come from a case that requires the same secrecy constraint on the planning. For a couple planning to run off to Las Vegas and marry, coordinating plans is very important. However, if they are facing the opposition of their parents, a specific reminding such as the story of "Romeo and Juliet" would provide the knowledge that they must let each other know about the plans and that they must keep the plans a secret from their opponents. In this way, an old episode may provide additional infor-

mation comparable with the new situation; for example, actions from the old situation that might be possible in the new, problems to watch for, and specific expectations about what will happen. The information at the *TOP* level is kept general in order to apply to all cases; therefore, remindings of particular cases could provide additional information.

Fourth, reminding plays a role in forming new generalizations. A reminding may provide some information not captured by the *TOP.* Because the *TOP* is built from previous cases, the generalizations it contains are those which proved useful at the present time. Other features may become important, and the generalizations of the *TOP* can be changed as new cases are added which highlight specific features. Thus, in a new episode, some feature may become more important, although it was left out of previous generalizations. The reminding then adds to understanding by pointing out similarities in the two experiences that had not been noticed. In this manner, the information in the *TOP* can be changed to reflect new features.

Without the benefit of case information, drawing appropriate generalizations and determining the limits of their application would be impossible. Cases are needed to form appropriate generalizations; therefore, the crucial role of reminding is to guide the process of learning. Consider this example (Schank & Seifert, 1985):

> X was walking along a beach in Puerto Rico at dusk when he noticed a sign on the beach saying, "No swimming at this point." Yet everyone was swimming happily and it was clearly safe. X walked along further and came upon a new sign saying, *Don't go beyond this point. Dangerous!* X explained this to himself by assuming that the hotel had put up the signs to try to cover itself legally in case of an accident. At this point X was reminded of the signs in Connecticut that say, *Road legally closed, pass at your own risk,* when the road is in full use. X had previously explained these signs to himself by saying that the state of Connecticut, in the event of an accident, wanted to be able to say the road was legally closed, and that they therefore were not responsible.

Once X had explained the hotel signs as an attempt to cover any legal liabilities, the previous experience with the same explanation came to mind. From the two examples, X could make the generalization that institutions, such as states and hotels, are likely to take such steps to protect their liability. However, from only one experience it would be difficult to tell how far to generalize the expectation—to all states? to governments? to road owners? The role of the reminding is to help make the appropriate generalizations, and the second experience is quite functional in constraining and guiding the generalization. Of the many features available, it is important to establish which ones are most relevant. What X had to do with the hotel example is decide that the most relevant feature is protection of one's legal liability through signs.

Thus, the information from a particular episode is very important for the purposes of generalizing across contexts. In order to learn what goal and plan information is important in a particular situation, a related episode can be contrasted to determine what the similarities are. With another episode to serve as a guide, the appropriate generalization can be formed. It is this mechanism of reminding that serves as the basis for learning. However, remindings can serve an important function even after particular *TOP*s are well learned—namely, filling in specific knowledge from very similar cases.

Thus, we constantly receive new inputs and evaluate and understand them in terms of previously processed experiences. Why have these prior experiences been labeled in such a way that they show up at the right times? Consider the similarities between the Minister story and the Karen's Coach story about hypocrisy, discussed in the last section. How must they be organized in memory in order to have one remind you of the other? These two stories have a lot of features—smoking, pornography, publicity, even warnings—that will not be very useful in finding one memory based on the other. However, at the thematic level, the *TAU HYPOCRISY* structure outlined above captures the crucial similarity via the relationships between the goals in the episodes and the interesting deviations in the situation. Features of that goal pattern in one story can activate the *TAU* structure, and may activate the other story stored with the *TAU.* When an episode involves a complex goal pattern, similar episodes that had been understood using that goal pattern may be brought to mind. One is reminded of a particular experience because the structures one is using to process the new experience are the same structures one is using to organize memory. Thus, Schank (1982) proposes, while processing a new input one cannot help but pass through the related previous experiences in memory.

A Process Model of Reminding

How is it that we bump into episodes as we process new experiences? We would like a process model of how episodes are activated through structures. What is the nature of the connections between the structures and the episodes that build them? One possibility is that episodes are immediately activated as a consequence of the activation of a knowledge structure. This view is similar to a model of semantic memory, where related concepts are activated by accessing a node in memory. It appears that the activation of an episode will directly affect the structure that stores it; however, the connections between episodes may be of a different quality. When is a structure accessed and when is a case activated or retrieved? Under what processing conditions is information from episodes likely to be useful; that is, when is reminding most likely to occur?

Let's examine a proposal for how episodes may be stored under thematic knowledge structures. Consider these two episodes from Dyer (1983), both based upon the thematic pattern in the adage "Closing the barn door after the horse has gone."

Academia:

> Dr. Popoff knew that his graduate student Mike was unhappy with the research facilities available in his department. Mike had requested new equipment on several occasions, but Dr. Popoff always denied Mike's requests. One day, Dr. Popoff found out that Mike had been accepted to study at a rival university. Not wanting to lose a good student, Dr. Popoff hurriedly offered Mike lots of new research equipment. But by then, Mike had already decided to transfer.

Hired Hand:

> The hired hand wanted a raise, but the farmer would not grant it. Finally, the hired hand got an offer to work at a neighbor's farm. When the farmer found out, he offered the hired hand a raise, but it was too late.

The similarity in the two stories involves some general planning information about a common error: waiting too long to act. The general information in the *TAU* structure proposed by Dyer (1983) to capture these two episodes is represented as:

TAU-POST-HOC:

1. X has a problem situation active;
2. X knows a plan that will solve the problem and prevent a negative event;
3. X does not execute the plan and the negative event occurs;
   X attempts to recover from the failure by executing the plan now;
   The plan fails, because it is effective in *avoiding* negative events, but not in *recovering* from the negative event;
4. In the future, X must execute the plan *before* the negative event occurs.

Given the two episodes, and a general structure to encode them, the resulting organization in memory is suggested to be similar to the following pattern (Dyer, 1983):

Recalling an episode involves activating the associated structure, with

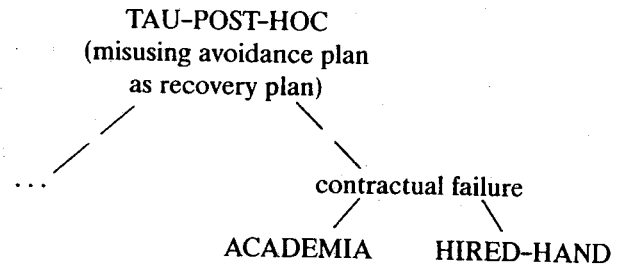

FIG. 8.1. The memory organization of a TAU structure and related episodes.

its related inferences and information. This is due to the encoding of each episode in terms of its organizing structure (Bartlett, 1932; Alba & Hasher, 1983). This schema-activation hypothesis suggests that accessing an episode stored under an organizing schema also activates the schema itself. However, the question of when an episode is accessed, given an activated schema, remains unclear. Similarity between episodes serves as the basis for structures; yet, episodes that share structures may or may not activate each other. The conditions under which an episode may remind one of another may depend on more than the thematic structure they share.

We considered four possibilities based upon the model of memory we have discussed above:

1. The current story may activate the abstract *TOP* structure, and through it the previous story; reading the Academia story will activate the Hired Hand story.
2. The current story may activate the previous story either as a whole or by parts as the episodes are matched, and through them the *TOP* may be activated.
3. The current story may activate the *TOP,* but no other episodes.
4. The current story may activate neither the *TOP* nor the other episodes.

In the first two cases, activation might lead to connections in memory between current and previous stories. In the third, in order to traverse the connections between structures and episodes, either more information or different processing demands may be necessary.

Fairly strong claims have been made about the circumstances of reminding and understanding. One theory of memory suggests that "we cannot help but pass through the old memories while processing a new input" (Schank, 1982). This approach implies that related episodes must be activated when a structure is accessed. Whether or not a conscious reminding occurs, the connections between episodes through their shared knowledge structure may result in activation. In a series of experiments, we set out to test the

hypothesis that thematic knowledge structures determine the organization of episodes in memory. Specifically, we would like to determine whether related episodes are automatically activated when the structure is utilized. If not automatically activated, under what circumstances do episodes that share a structure activate each other? This question called for a novel approach to investigating reminding.

EXPERIMENTAL REMINDING

An important initial task was to create an experimental methodology that could provide some answers to these and other questions about memory. How can we move the phenomenon of reminding into the lab? Examining reminding empirically depends on developing both a naturalistic task that is analogous to reminding in the real world and a successful measure of the activation of episodes. Success in experimentally demonstrating whether and when a previous episode is called to mind depends on a naturalistic task. How can we manipulate when and how people are reminded so that it will occur during the experiment? What are the appropriate control conditions? How can we accurately measure what people are thinking about?

A novel approach was required to provide a convincing display of reminding. Tight controls are probably impossible when testing the kinds of questions that we are interested in. We cannot control a person's whole set of life experiences for the purpose of a psychological experiment. This concern has led psychologists to develop laboratory experiments to test natural task performance. Another concern is the variety of memory structures that each individual will have formed, as they are based on the individual's experiences.

Our goal was to attempt to get subjects to pass through old memories while processing a new input. We decided to present episodes that were verifiably "thematically similar," and measure whether subjects made connections between the episodes. If two similar episodes were presented to subjects, one after the other, would they encode them using the same thematic knowledge structure? And, if they did so, would they be "reminded" of the first episode when encoding the second? For example, if subjects first read the Academia story, and then read the Hired Hand story, would the two stories be connected in memory? Would reading the Hired Hand story activate (cause a reminding of) the Academia story? This method should determine the degree to which reminding is spontaneous during reading.

Methodology

In our experimental paradigm, subjects were asked to read a series of stories that were based upon thematic structures. The question addressed was whether the stories are connected in memory based upon their thematic similarity. In a series of experiments, we examined the circumstances under which previous story episodes were activated. In each of the experiments, subjects read stories based upon *TOP* structures. We examined what happens when the story that is currently being read has the same *TOP* structure as a previously read story.

We needed a way to measure accurately the reminding, or the activation, of the previous episode. Priming in item recognition has been shown to be a successful methodology for determining if concepts are active in memory (McKoon & Ratcliff, 1980a). In the experiments presented here, priming is used as a measure of the activation of target episodes in memory. The degree of relationship between the two concepts in memory is measured by the response time for one when preceded by the other. If two items are connected in memory, answering a question about one will prime the process of answering a question about the second. So, using our previous example, a question about the Hired Hand story may be asked, and immediately followed by a question about the Academia story. If the two stories are connected in memory, responding to the first question should facilitate responding to the second. Response time to verify an item (answer "true" or "false") should reflect the item's relation to the just-preceding item. If the two test items come from thematically similar stories, and are therefore connected in memory, the response time should be shorter compared with the case where the two items are from unrelated stories.

We also needed materials that were close to naturalistic episodes while being manipulable for our purposes. As discussed above, the *TAU* structures defined by Dyer (1983) seemed to fit our requirements. Because *TAU*s are based upon common adages, their content reflects cultural knowledge that could be familiar to our subjects. The set of *TAU*s we employed involved planning errors captured by familiar adages such as "counting your chickens before they hatch," "closing the barn door after the horse is gone," and "the pot calling the kettle black." While the *TAU*s captured similar themes, they were also distinct from each other. In order to have pairs of stories with similar themes and pairs with dissimilar themes, the themes had to be discriminable. Thus, we selected a set of *TAU*s which seemed to involve the same kind of planning knowledge while being discriminable from each other. This was supported by the experiments discussed earlier, where subjects were able to sort the stories sharing a *TAU* into the same group, and did not group stories across *TAU*s (Seifert and Black, 1983).

In Experiments 1 and 2, priming was used to test for memory connec-

tions between elements of two stories. The two stories were read one after another, and then a test list of items was presented. In the comparison of interest, two items, one from each story, were presented one after another in the test list. If the two stories are based on the same thematic structure, verification of an item from one story might speed verification of a similar element from the other related story.

In Experiments 3 through 6, we tested for activation by presenting a single test sentence immediately after a story was read. If the test sentence is from a previously read story with the same *TAU* structure as the story just read, response time might be speeded because the previous story had been activated. The following is an informal description of the experiments; a complete explication is available in Seifert, McKoon, Abelson, and Ratcliff (1986).

Experiment 1. The question we investigated is whether information in a text is encoded with respect to previously read episodes that have the same structure. Is a previously read episode activated and is information from a previously read episode connected in memory to the new episode? In our first experiment, subjects read lists of story pairs based on *TAU* structures. We hypothesized that if two stories based on the same *TAU* were connected in memory, then a sentence from one of the stories should speed response time for an immediately following sentence from the other story.

Twenty subjects were asked to read a series of story pairs presented one at a time on a computer screen. Stories in the Same-Theme condition were paired with a story based upon the same *TAU* pattern, and stories in the Different-Theme condition with stories based upon a different *TAU* pattern. On each of the 44 trials, they read two stories and then responded to eight test sentences about those two stories. The task was to respond, by pressing a key, whether each test sentence was "true" or "false" according to the story it was from. For each of the stories, there were four test sentences: the "conclusion" sentence of the story, a true filler and two false fillers. For example, the conclusion or outcome for the story about the graduate student in Table 8.1 was "by then, Mike had already decided to transfer." The critical priming pair was the conclusion sentence from the first story immediately followed by the conclusion from the second. If the two stories share the same *TAU,* verifying the conclusion sentence from the first story should speed the verification of the conclusion from the second story, compared with the response times when the stories do not share the same *TAU.*

A control condition showed that two items from the same story *did activate* each other relative to items in the same presentation pair but not the same story. Thus we have an indication that our methodology is sensitive enough to register connections in memory, replicating previous work

TABLE 8.1
Sample Stories

Dr. Popoff knew that his graduate student Mike was unhappy with the research facilities available in his department. Mike had requested new equipment on several occasions, but Dr. Popoff always denied Mike's requests. One day, Dr. Popoff found out that Mike had been accepted to study at a rival university. Not wanting to lose a good student, Dr. Popoff hurriedly offered Mike lots of new research equipment. But by then, Mike had already decided to transfer.

True filler: Popoff always denied the requests for equipment.
Conclusion: By then, Mike had already decided to transfer.
False filler: The doctor was known as a terrible researcher.
False filler: Mike decided to buy his own research equipment.

Phil was in love with his secretary and was well aware that she wanted to marry him. However, Phil was afraid of responsibility, so he kept dating others and made up excuses to postpone the wedding. Finally, his secretary got fed up, began dating and fell in love with an accountant. When Phil found out, he went to her and proposed marriage, showing her the ring he had bought. But by that time, his secretary was already planning her honeymoon with the accountant.

True filler: Phil made up excuses to postpone the wedding.
Conclusion: His secretary honeymooned with an accountant.
False filler: Phil didn't even know she wanted to get married.
False filler: Phil proposed marriage with no ring to offer.

(McKoon & Ratcliff, 1980a) that showed that the elements of an individual story are connected to each other. However, when verifying the conclusion of a story, preceded by the conclusion of another story, it made no difference whether the stories expressed the same theme or a different theme, F's < 1 for both response times and error rates. Mean response time was 1538 ms (3 % errors) in the Same-Theme condition, and 1516 ms (5 % errors) in the Different-Theme condition.

Experiment 1 thus failed to demonstrate an effect of thematic similarity upon verification time. While the similarities in the stories appear quite salient, especially when presented in pairs, this manipulation did not affect the time to verify the conclusion of one story when preceded by the conclusion of the other. Apparently, either subjects did not recognize the intended similarities, or if they did, elements of similar stories were not connected to each other. In order to determine if subjects were at all able to make use of the thematic similarity in the story pairs, a second experiment was designed to stress the use of the themes in understanding the stories.

Experiment 2. In this experiment, we attempted to encourage subjects to recognize and use the thematic similarities in the story pairs by providing explicit instructions about thematic similarity.

Twenty subjects participated in an experiment identical to Experiment 1, but with two additions. First, they were given specific instructions about the themes in the stories. While in Experiment 1, no mention of themes was made to subjects, in Experiment 2 they were given a description of the type of themes used in the experiment and an explicit example of theme in a story, and were told to think about the theme of each story. Second, the subjects rated the similarities of the stories after each test list on a seven-point scale, 1 meaning very different and 7 meaning very similar.

In contrast to Experiment 1, response time for a conclusion was faster if it was primed by another story conclusion with the same theme rather than with a different theme. Mean response time was 1567 ms (10 % errors) in the Same-Theme condition and 1649 ms (14 % errors) in the Different-Theme condition. This difference was significant with subjects as a random factor $F(1,19) = 4.7, p < .05$, and marginally significant with test sentences as a random factor, $F(1,46) = 3.2, p = .10$. The difference in error rates was not significant. The similarity ratings from Experiment 2 show that the subjects were reliably able to detect the intended thematic similarity in the story pairs. For the Same-Theme pairs, the mean rating was 6.19; for the Different-Theme, the mean was 2.97. In Experiment 2, subjects did make use of the thematic similarity in the story pairs, resulting in a marginally significant effect of the thematic connections between the stories. This effect was found when subjects were instructed to consider thematic similarity while they read (in Experiment 2), but not in Experiment 1 when they were not so instructed.

Experiment 2 shows that subjects are sensitive to the thematic structures of these stories. Intuitively, the thematic structures must be accessed to understand the story, because to the extent that the thematic structure captures the point of a story, failing to recognize the thematic structure is failing to understand the story completely. In addition, our measure of activation was sufficiently sensitive, as shown by a control condition. Therefore, we argue that subjects do understand the themes in the stories even without specific instructions, but that this understanding does not automatically provide connections between elements in two instances of the same theme. Instead, it suggests that the connections between episodes require some strategic processing during reading (as in Experiment 2).

Experiments 3 and 4. Experiments 1 and 2 are subject to the criticism that the testing occurs *after* both stories have been encoded into memory; the testing is separate from the reading process. Because of the need to test for activation of the previous episode *during encoding,* two more experiments were designed to test for priming immediately after reading the

second story. In this design, the second story itself functions as a priming item for the test sentence from the first story in the pair. In an attempt to pace the comprehension process so that all subjects were encoding the last line of the story just prior to testing, the stories were presented word by word at a natural reading rate.

In these two experiments, each subject read a series of stories on a computer screen, some of which were followed by a single test sentence from the immediately preceding story, to which the subject responded "true" or "false" as in Experiment 1. Two stories presented one immediately after the other could have either the same or different thematic structures. In Experiment 3, as in Experiment 1, subjects were given no specific instructions about the themes of the stories. In Experiment 4, as in Experiment 2, subjects were given instructions about the themes in the stories, a rating task, and a few extra seconds of reading time for each story.

The hypothesis, as in Experiments 1 and 2, was that subjects would be faster to verify the conclusion of a story when it was presented immediately following a story with a similar theme (Same-Theme condition). However, in neither experiment was there a significant effect. The respective means for the Same- and Different-Theme conditions were 1659 ms (8 % errors) and 1659 ms (8 % errors) in Experiment 3 and 1698 ms (6 % errors) and 1752 ms (8 % errors) in Experiment 4. While the difference in Experiment 4 was 54 ms, it was not significant ($F(1,19) = 2.4$ with subjects as the random variable) and for only 11 of the 20 subjects was the difference in the right direction. Subjects in Experiment 4 were reliably able to detect the intended thematic similarity in story pairs: for Same-Theme pairs, the mean rating was 5.85; for the Different-Theme pairs, the mean rating was 2.90.

When test sentences were presented immediately after a story was encoded, there was little evidence of the activation of thematically similar information. Even in Experiment 4, where specific instructions were given and ratings indicated that subjects did recognize the intended thematic similarities, they were simply unable to make use of the similarities they saw. When a story is presented word by word, as in Experiments 3 and 4, it may be much more difficult for subjects to invoke either the encoding processes needed to set up the memory representation for later retrieval by a thematically similar story or the retrieval processes necessary to find such stories. In Experiments 5 and 6, we attempted to make these processes easier by giving subjects extensive study on the stories that would later need to be retrieved by thematic similarity.

Experiments 5 and 6. In these experiments, subjects prestudied a set of stories. This set was intended to be the experimental analogue to a set of previous experiences in memory. Each prestudied story was paired with two test stories: one based on the same *TAU* as the prestudied story, and

one based on a different *TAU*. For both stories, the test sentence was the conclusion of the prestudied story, as shown in the examples in Table 8.1. We hypothesized that, in the Same-Theme condition, reading a test story with the same thematic structure as the prestudied story may remind subjects of the old story, leading to faster response times for the test sentence.

There were three phases to Experiments 5 and 6, a prestudy phase, a study-test phase, and a final free-recall phase. In the prestudy phase, subjects were asked to read and summarize eight target stories, each of a different *TAU* pattern. In the study-test phase, new stories were presented word by word and were followed by a test sentence which always referred to one of the prestudied stories. Eight of the new stories were paired with the eight prestudied stories so as to have the same thematic pattern (Same-Theme condition), and another eight were paired with the prestudied stories so as to have a different thematic pattern (Different-Theme condition). Thus, each conclusion sentence from a prestudied story was presented for testing twice, once in the Same-Theme condition and once in the Different-Theme condition, counterbalanced for order of presentation.

Two different tasks were used as reaction-time measures. In Experiment 5, subjects made a true/false decision as in the other experiments. In Experiment 6, an identification task was used; subjects pressed a response key as soon as they could remember which story the test sentence referred to. After responding, they wrote a one-sentence description of the story referred to by the test sentence. In the final, free-recall phase of each of the two experiments, subjects were asked to recall the prestudied stories. Eighteen subjects participated in Experiment 5 and eight in Experiment 6.

In both experiments, responses in the Same-Theme condition were faster than responses in the Different-Theme condition. In Experiment 5 (verification), the mean response time in the Same-Theme condition was 2376 ms (3 % errors), and in the Different-Theme condition, 2554 ms (1 % errors). This difference was marginally significant, *min* $F(1,15) = 3.8$, $p < .08$. The difference in error rates was not significant. In Experiment 6 (identification), mean response time in the Same-Theme condition was 1253 ms, and in the Different-Theme condition, 1474 ms. These means were significantly different, *min* $F(1,14) = 5.4$, $p < .05$. All subjects had completed the accuracy check of writing an identifying phrase from the story after hitting the response key. In the final free recall phase, subjects were able to generate 75% of the prestudied stories in both experiments.

These experiments provide strong evidence for the effect of thematic similarity in activating previous episodes. In both the verification task and the simpler identification task, response times for a test sentence from a prestudied story were faster when the story preceding the test sentence matched the test sentence's story in thematic structure. New stories appeared

to activate stories already encoded in memory on the basis of their thematic similarity.

Conclusions from the Experiments

In our experiments, we sought to determine some of the circumstances under which reminding occurs during reading. We wanted to know whether activation and connection processes during reading were automatic or strategic encoding processes. Schank (1982) has claimed that schematic information like that represented by *TAU*s is automatically activated and automatically connected to other schematically similar information in memory.

Our conclusion was that a story currently being read does not automatically activate a thematically similar (previously read) story, nor are elements of the two stories automatically connected to each other. However, when subjects were encouraged with instructions, then there was weak evidence that the connections were made. Further, when instructions were combined with extensive prestudy, strong evidence for the activation of thematically similar episodes was observed. These experiments show that thematic similarities can serve as the basis for reminding when there is a functional purpose of reminding in the task. The conditions under which activation and connection occur appear to depend on the strategies in which subjects engage during reading, and the ease of remembering old episodes. When subjects are not encouraged to remember previous episodes, there is no evidence for activation or connection. However, when subjects are encouraged with instructions, then there is weak evidence that the connections are made. Finally, when there is a built-in purpose for reminding in the task, as in Experiments 5 and 6, activation of episodes is functional to the task and subjects have no trouble activating the episodes in memory.

THE FUNCTIONALITY OF REMINDING

We propose that the significance of these results lies in the demonstration of the functionality of abstract memory structures. It appears that one thematic episode does not automatically activate or become connected to another similar episode. Rather, strategic processing seems to be involved. When subjects in Experiment 1 were not given instructions to rate the thematic similarity of the stories, there was no reason for one story to bring to mind a similar story. But such reminding became functional when the rating task was introduced (Experiment 2). Similarly, in Experiments 5 and 6, remembering the prestudied stories was functional because all of the test sentences came from those stories. Thus when

recalling previous episodes serves a function, this type of strategic processing may be observed.

Do our experimental results alter the conception of reminding expressed by Schank (1982)? Schank focused on the role of reminding in *understanding* new episodes. In that view, understanding meant "being reminded of the closest concept in memory to the one being processed." It was not clear whether episodes that share structures activate each other or under what conditions the activation of the episode was likely. We have seen that while two episodes can activate the same structure during encoding, they do so only under certain circumstances. That is, when there is a built-in functionality or processing goal to consider case information, reminding will occur.

Intentional Reminding

Schank (1982) proposed three conditions in which remindings occur:

1. Current structures can't handle the case, and you are forced to learn a new structure;
2. An episode serves as the structure due to its prototypical nature;
3. Under some circumstances you can be intentionally reminded.

Our results suggest that, at the least, intentional reminding plays a much bigger role than previously indicated and seems to be the best prospect for further experimentation. In this type of reminding, processing is directed by a desire to call a relevant past experience to mind. It is an attempt to come up with a relevant experience that will help to understand the current situation. "Intentional" is not meant too literally; that is, it is not always consciously intended, but can come from just thinking about a situation in a particular way. For example, consider conversation: an understander seeks, in the processing of new input, to be reminded of a memory that relates to what he or she heard and provides substance for a reply. In intentional reminding, whether a conscious search process or not, accessing a previous episode is fostered by implicit goals in processing. These goals, part of particular tasks, make the recall of episode information more likely. Rather than relying on the structural generalizations needed for simple expectations, some tasks require more specific case information. Therefore, the goals in processing are more likely to lead to recalling previous episodes.

The issue of the functionality of reminding suggested by these experiments is reminiscent of previous work with analogies. For example, Gentner and Tenney (1984) have found little evidence for the spontaneous use of analogies such as water for electricity where neither domain is well understood. Schustack and Anderson (1979) found that recognition of facts about fictional persons was not helped by analogies with famous people

unless the analogy was pointed out, both at the time the facts were studied and were tested. Likewise, Gick and Holyoak (1980, 1983) have found that subjects are not likely to be able to use the analogy between a story they study that contains a solution and a problem that needs a similar solution, unless they are instructed or given more than one story to study. We think that the similarities between two thematically similar stories in our experiments are much more obvious than the similarities in either Schustack and Anderson's or Gick and Holyoak's experiments. Yet, subjects were not able to use them without aid (instructions and/or prestudy). Thus, the present experimental results suggest that the functional purpose of reminding and analogy must play a role in determining when it occurs.

What functions do remindings serve? What kind of processing goals are implicit in these tasks that would foster reminding? If you look closely at the remindings people offer, you can see how they are used to augment general principles. Consider this example reminding:

> X was analyzing the problem of how they got Mr. Ed to speak on the old TV show. She contended that it was easier to train a horse to talk like a person than to take a person and teach them to be a horse. She was then reminded of a situation that occurred in Paris where training was required. An opera company there was putting on a Russian production and needed singers who knew Russian. Because the singers had such difficulty with the Russian, they rounded up all the Russian cab drivers in Paris and taught them to sing. X then said, "training a horse to talk is no worse than training Russian cab drivers to sing when opera singers couldn't learn Russian."

In this case, the general principle of "reversing the training because it is a simpler proposition" is evident in the horse example. However, the reminding of the Russian singers serves the function of buttressing the argument and adds a claim about its feasibility ("it's not worse than . . . "). Thus, in this example, being reminded made the argument stronger by providing an actual experience where X's claim is supported. In a second example, the reminding plays the role of supporting a proposed plan by providing an example of its successful previous application:

> Y was lamenting that it was awful to be at Teletrack, the local indoor betting arena, due to the smokers who were impossible to avoid. Smoking is, in fact, prohibited at Teletrack, but everyone ignores that and consequently smokers are spread all over the arena. The authorities try to ban all smoking and are unable to control it. Y proposed that he should ask that smoking be allowed at Teletrack; if smoking were allowed, smoking and nonsmoking sections would have to be designated and Y would have a section where he wouldn't have to sit next to smokers. Z was then reminded of the action England took to control the use of heroin in the country: under a complete ban, the use was

not controllable. Once it was legalized, the government had control over those who needed to buy the drug.

Z's reminding serves the function of supporting the proposed plan with an example of its success. The claim that restricting smoking produces the end result of a smokeless section better than prohibiting it is supported by the heroin control in England. Without the reminding, it might be hard to reason out the possible effects of the plan.

Remindings can serve a variety of functions in particular tasks. For example, in conversation, a response is formulated that puts forward a point of view. In order to express the view without totally disregarding the question asked, relevant information from memory must be found that relates the topic asked about to the point of view. *TOPs* are needed so that specific inputs can be processed by general structures containing memories that relate to those inputs in an interesting way. Formulating a good response often requires one to draw analogies from other contexts. The rules the speaker has for responding require relevant memories upon which to operate. The understander seeks, in processing of new input in conversation, to be reminded of a memory that relates to what was heard and provides evidence for the point of view to be defended.

Remindings can serve to verify your analysis of an episode, illustrate why your reasoning is valid, justify or support a claim, give specific solution information, and perhaps provide an analogy that may be revealing. Thus, finding a reminding can be a much more active process than accidental fallout from understanding, and may be required by rules and strategies in the reasoning process.

Goals Foster Reminding

Some tasks being modeled in computer programs may assume reminding occurs with every input. For example, in the *CYRUS* program (Kolodner, 1984), the goal was to retrieve a particular episode in memory given a set of features. Reconstructive strategies were applied to the memory network of episodes and structures to retrieve an episode whenever enough features distinguished an episode from its organizing structure. Clearly, retrieval of episodes through *TOP* structures alone will not occur very frequently. As discussed earlier, experiences will not serve as great a function, and therefore be recalled less frequently, when the *TOP* structure is well learned. Therefore, while activating a *TOP* in memory will not frequently be likely to cause a reminding, some types of processing goals may be more likely to produce remindings. If we look carefully at the tasks chosen to study reminding through computer simulation, we can discover the kinds of strategies in reasoning that make use of remindings, and are therefore more

likely to produce them. Implicit goals in reasoning processes that make use of remindings may foster the retrieval of experiences from memory.

The kinds of tasks which utilize case-based information have implicit goals to guide processing. For example, the *JUDGE* program (Bain, 1984) attempts to determine a fair sentence for an offender by evaluating all possible information. Both thematic structures, such as justification strategies (i.e., *Parity Retaliation,* where a victim strikes back to an equal degree of harm to offender and victim), and previous instances play a role in the reasoning process. In this task, previous experiences are very useful in evaluating possible outcomes of a sentencing. In fact, the judge's responsibility is to try to find the best sentence to make certain outcomes more likely; therefore, remembering past cases where particular sentences had particular results would be very useful. In addition, remembering cases is important in trying to maintain some consistency in sentencing across individuals.

In the *WOK* program (Hammond, 1983), the goal of creating a new recipe guides the search in memory for useful information. Comparing past recipes based on a new dimension is an important part of being creative, and, therefore, the need to examine past cases is an important part of the process. For example, a failure situation will be analyzed to help search memory for a solution. In the *beef and broccoli* example from this program, cooking the items together fails because the meat produces too much water for the broccoli to handle. This problem of a side-effect of one goal interacting with the carrying out of another goal is captured by a *TOP* structure. Using the structure as a starting point, memory is searched for other plans that would prevent this side-effect. Through some search strategies, the program comes up with a plan used before to cook two things that have different cooking times, such as pork and snow peas: cook the two ingredients separately. In this type of task, where the creation of new plans occurs by comparing past successes and failures, reminding as a strategy is very important.

What types of tasks will include processing goals that promote remindings? Clearly, any type of problem-solving task will tend to require the kinds of processing demands we have been discussing. In situations where complex situations are represented by prototypes, recall of episodes will be important. For example, in the legal domain, cases often stand as prototypes for decisions, and lawyers need to recall cases as exemplars to formulate arguments. Reminding is the basis for analogical thinking, and in situations where there is a lack of domain knowledge, drawing upon past experiences that share some similarities will be necessary.

In complex problem-solving tasks, where detailed reasoning is required, remindings can aid in thinking through the factors involved in the problem. For example, in the domain of psychiatric diagnosis, where complex infor-

mation is available to be considered, recall of previous cases may suggest correlations not previously observed (Kolodner & Simpson, 1984). Finally, in examining alternative conceptualizations or scenarios, possible solutions can be used as memory indices to find past instances where the solutions were tried, and the resulting episodes can be compared to the current instance.

Modeling these types of tasks will likely give us better access to the reminding process. Because of their intentional nature, they are likely to provide more instances of reminding across contexts. If we look for the kinds of processing goals that foster reminding, we are likely to find rich problems that will involve interesting knowledge structures and strategies for finding cases. Further, these kinds of tasks are likely to be more amenable to psychological experimentation in the laboratory. "Strategies" in experimental settings have been viewed as negative factors that impede the measurement of some more interesting process. However, some strategies are very interesting and integral parts of the reasoning processes we are interested in studying. By focusing on a naturalistic task, and devising news ways to test hypotheses in the laboratory, these strategies can be investigated as they function in reasoning.