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INTRODUCTION TO COGNITIVE SCIENCE

MEETING 10

MEMORY

I. A Brief Review

There are three stages in memory that need to be considered separately: (1) the **acquisition** of information that can be committed to memory; (2) **storage** or **retention** of that information in memory (leading to the forming of a memory "trace," i.e., a permanent representation of the information acquired); and (3) **recall** or **retrieval**, where the information stored in memory is made available to active mental processes. These stages need to be considered separately because memory can fail or otherwise be affected at any or all of these stages.

The stages described above refer to processes related primarily to long-term, declarative memory. As we saw in earlier chapters, cognitive scientists typically postulate other sorts of memory. First, there is **working memory**, which contains representations that are readily available to active cognitive processes. Working memory is limited to three or four separate "chunks" of information, and it is volatile: whatever moves out of working memory is lost forever unless it is first stored in long-term memory. Second, there is **long-term declarative memory**, which stores declarative (factual) knowledge in a permanent form that can be retrieved to working memory later. The propositional (semantic) network models described in Chapter 2 are a model of long-term memory as representation in a propositional network, with retrieval occurring as the result of spreading activation originating in working memory. Finally, there is **procedural memory**, which stores knowledge related to skills. As we saw in Chapter 2, procedural memory may be thought of "chunked" or "compiled" instructions encoded in **productions**, or condition-action rules.

II. Factors and Processes Influencing Memory Formation

There are many different factors influencing memory formation and later retrieval. The first involves the strategy that is following in the original formation of the memory. One can, for example, follow the strategies of either **rehearsal** or **elaboration**. Rehearsal occurs when a person keeps the information to be remembered continuously in short-term memory, e.g., by repeating it over and over. Elaboration occurs when the information to be remembered is related and linked to other elements, e.g., by embedding that information in a larger, coherent story, or (more generally) a richer informational environment. For example, there are simple visual "mnemonic devices" (memory aids) that have been found sometimes to improve memory. If asked to remember unrelated word pairs, such as dog-chair, a person might rehearse the pair by saying it many times "to himself" (rehearsal) or he may form a vivid visual image of a dog jumping up and down on a chair (a form of elaboration). The latter procedure sometimes helps retention of the information. Elaboration may also occur by embedding the information in a larger story or narrative. In general, stories that describe a cause-and-effect sequence are more effective memory aids than simple visual imagery. For example, if asked to remember the statement that Mary helped her brother to buy a chair, a person might elaborate the statement by imagining it as an element in a larger story or narrative, e.g., that Mary was an interior decorator who had special expertise in furniture, and that her brother John was buying his spouse a special reading chair for her birthday but felt insecure about his tastes in furniture and so asked Mary to help, and so on. This of course creates the problem during recall of separating out the original information from the elaboration. Presumably, the original information would somehow have to be "tagged" as such or else elaboration might easily lead to confusion. A person would have to use the "tags" to reconstruct the information to be remembered by extracting it from the larger context.

Which procedure, rehearsal or elaboration, is more effective? It depends on to what use the procedures are going to be put. An interesting experiment by Bjork (1975) showed how the different procedures might be used. Bjork tested subjects' memory of sets of 6 common, four-letter words. Subjects were divided into two groups, each of which was encouraged to use one of the strategies of rehearsal or elaboration. Subjects studied the words for a while, and then the list was removed. After a 20 second delay, subject were asked to recall the items on the list. Each person participated in 20 such trials. At the end of the experiment, without warning, participants were given memory tests of items from all 20 groups they had seen. At this point, each group (rehearsal or elaboration) was further subdivided into two groups, one of which was given a **free recall memory** test ("try to come up with as many words from the 20 sets as you can"), and the other of which had a **recognition memory** test (that is, picking a word that was in the 20 sets from among several "distracters," which were not).

The overall results of Bjork's experiment was as follows. Rehearsal was found to be a more effective strategy for remembering items after each 6-word set trial (that is, after a single 6-word set was studied and then removed for 20 seconds before recall was attempted). However, elaboration seemed to be much more effective for the later recall, which occurred after all 20 trials had been completed. Subjects who used elaboration could freely recall twice as many words as those who had used rehearsal strategies. In recognition tests, elaboration was also a better strategy, though recognition of those who had used rehearsal was reasonably good. "The results ... demonstrate that the elaboration strategy produces much better long-term recall performance and somewhat better long-term recognition performance" (CS, page 101).

It is worth mentioning that the deeper the level of semantic processing that is required of subjects when they first encounter information, the more likely the information is to be retained (Craik and Tulving 1975). In other words, the more deeply subjects think about the meaning of the information to be remembered and its relation to other concepts and other information, the more likely they are to remember it. (This is also a form of elaboration, semantic rather than narrative.) The **intention to remember** seems to have little effect on retention. That is, if some subjects are asked to try to remember the items in the list for a later memory test, and others are not, will it affect later recall, or are the memory formation strategies subjects use (based on the semantic depth of processing) the only relevant factors influencing recall? The experiment by Craik and Tulving (1975), and another by Hyde and Jenkins (1973) seem to indicate that semantic depth of processing is the only relevant factor. There was no difference in recall abilities between those who were told to try to remember the information for a later memory test and those who were not.

III. Schemas and Memory

As the experiments above show, elaboration (both narrative and semantic) seems to promote the formation of long-term memories. But why? An answer that is consistent with the propositional network model first outlined in Chapter 2 of CS, with its spreading activation model of recall from long-term memory, is that if a proposition is linked to a large number of propositions, any one of those propositions can act to increase the activation of the original item. An isolated representation, by contrast, could only be activated directly. This suggests that schemas (including scripts) could be an aid in the formation of memories. Research by Owens, Bower, and Black (1979) suggests that this is in fact true. They showed that embedding short descriptions in larger contexts that are available in scripts improved retention. A related fact is that subjects who already have a great deal of schematic knowledge about a subject matter tend to be able to recall information about that subject much better than people who do not (Chiesi, Spilich, and Voss 1979). In Chiesi, Spilich, and Voss's experiment, for example, subjects with a great deal of prior knowledge about baseball were able to recall more facts from baseball stories than subjects who were not knowledgeable about baseball. As before, however, recognition memory was improved less by elaboration -- in this case in the guise of embedding the stories in a network of previously acquired knowledge -- than recall memory. In other words, deep knowledge of baseball was helpful, but did not make as much of a difference, when subjects were tested by seeing whether they could recognize story elements from a list of "distracters" than when they were asked to freely recall elements from the stories. (This is one reason why multiple choice

questions are generally easier than essays: they do not require knowledge as deep about the subject matter as do essays!)

IV. Errors Introduced by Elaboration and Schematic Processing

Unfortunately, while elaboration and schematic processing can help promote retention, it can also cause subjects to confuse information with its later elaboration, or with elements of a schema or script that were not originally present. We already saw this in Chapter 2, when it was shown that people tend to recall elements of stories as present when in fact they were not, when the story was part of a script stored in long-term memory (Bower, Black, and Turner 1979). Indeed, this was part of the evidence offered for the existence of scripts.

This means that, because of how human memory works, people have a capacity to "remember" things that never occurred. It is possible for people to remember things as being presented as part of a story when they are simply recalling those things from associated scripts. This is called a **source error**: people can become confused about the source of a memory (later testimony versus personal observation) when poor **source monitoring** occurs (that is, when information about the source of recalled information is not stored). When people form memories in situations where source monitoring is encouraged during memory formation (e.g., when they are told to explicitly remember the source for later testing, or when there is some feature of the source itself that is noteworthy, such as a purported lack of trustworthiness -- see Dodd and Bradshaw 1980, Greene, Flynn, and Loftus 1982, or Lindsay and Johnson 1989), they are less liable to such source confusions.

The fact that memory can be adversely influenced by distracting influences has been well-documented. Elizabeth Loftus and her colleagues (Loftus, Miller, and Burns 1978) showed that after subjects view an event, and then are given misleading verbal characterizations of the event, they can report events that were in the verbal characterization but not the event itself as having occurred. For example, if in a slide show a man was holding a hammer, but the verbal characterization said he was holding a wrench, many subjects later report mistakenly that the man was holding a wrench, more often than if they were not given a misleading verbal characterization (McCloskey and Zaragoza 1985). Loftus and Palmer (1974) showed that after seeing a film of an auto accident, people judged the cars to be moving faster when they were asked how fast the cars were going when they "smashed" into one another (versus when the "hit" one another); a week later, the first group of subjects were twice as likely as the second (32 versus 14 percent) to mistakenly "remember" having seen broken glass in the film (there was none). In another example, people often recall that they had voted in an election when in fact they did not (Abelson, Loftus, and Greenwald, 1992), presumably because this "fits in" better with their self-schema. In her article on "The Reality of Repressed Memories," Loftus sums up the research as follows (Loftus 1993, page 530).

> Since the mid-1970s at least, investigations have been done into the creation of false memories after exposure to misinformation. Now, nearly two decades later, there are hundreds of studies to support a high degree of memory distortion. People have recalled nonexistent broken glass and tape recorders, a clean-shaven man as having a mustache, straight hair as curly, and even something as large and conspicuous as a barn in a bucolic scene containing no buildings at all (Loftus and Ketcham, 1991).

This research is disturbing, since in many situations we rely on witnesses to give us insight into what "really happened" during an event. Lindsay (1990) has conducted research into whether subjects will make similar mistakes even if they are given ample source monitoring opportunities. In Lindsay's study, subjects were told that they would be given a memory test after having viewed an event in slides, so that they had to pay close attention to details. They were also told a verbal account of what they had seen, and were told when they heard the verbal account that it was wrong about everything that would be asked of them later on. Presumably, subjects were aware that the story could mislead them and were trying not to be influenced by

it. Subject were divided into two groups: one group ("low discriminability") heard the misleading verbal report (along with the injunction not to trust it) right after viewing the slides, and were tested for recall 48 hours later; the second group ("high discriminability") heard the story and the warning 48 hours later, just before their recall of the slides was tested. The results were that the low discriminability group was 3 times more likely than a control group (who did not hear a misleading story) -- 27 versus 9 percent -- to report seeing items that appeared in the story but not in the slide show. The high discriminability group, by contrast, did not differ significantly from a control group. Lindsay concludes that subjects in the low discriminability group experienced genuine source monitoring errors, despite the fact that they understood and tried to heed the warning not to report details from the misleading verbal story.


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