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Control Processes in Remembering

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This chapter examines some of the processes that take place in attempting to probe memory for a needed piece of information. In present-day conceptualization memory processes are divided into three phases: encoding, storage, and retrieval. Strangely enough, the distinction between storage and retrieval, so basic in current memory theorizing, is relatively new (see Baddeley, 1997; Roediger & Guynn, 1996). In classical, S-R learning theory, based primarily on animal research, storage, and retrieval were lumped together, and even the distinction between encoding and storage was not explicitly made. It was the extension of S-R principles to human verbal behavior that has brought to the fore the importance of distinguishing among encoding, storage, and retrieval.

Availability and Accessibility

The critical role of memory retrieval becomes apparent when we realize that the amount of information stored in our memory exceeds by far the amount of information that we can retrieve from it. In terms of the terminology introduced by Tulving and Pearlstone (1966), much more information is available in memory than is accessible at any moment. Thus, although we may momentarily fail to retrieve the name of an acquaintance, we may still be able to recall it on some later occasion or recognize it among distractors. The discrepancy between the availability of information and its accessibility to consciousness testifies for the critical role of retrieval processes—the ability to conjure up stored information.

Two observations illustrate this discrepancy. Tulving (1967) had subjects study a list of words, and their recall was tested three times in succession. Only about 50% of the words were recalled on all three tests. For example, a subject might recall words on the second test that he failed to recall on the first test.

A second observation comes from a study (Williams & Hollan, 1981) in which subjects spent one hour every day trying to recall the names of people with whom they had graduated from high school 4-19 years earlier. Subjects were found to recall new names after as much as 10 hours in the experiment, spread over two weeks! Clearly these names must have been available even in the first hour of the experiment.

These observations raise several questions: What prevented all the items ultimately recalled to surface right from the beginning of testing? What allowed them to become accessible later on? And more generally, what is the process by which people search for and recollect stored information from long-term memory?

In attempting to address these questions, we should note that although most of our knowledge about memory processes derives

from the use of relatively simple laboratory tasks, control processes in remembering are particularly transparent in the retrieval of information under naturalistic conditions, particularly when retrieval is laborious and prolonged. Therefore, this chapter will emphasize studies concerned with this type of retrieval despite the fact they do not always attain the methodological rigor characteristic of laboratory experimentation.

Retrieval as Problem Solving

Even a cursory examination of everyday episodes of recollection suggests that there is much more to remembering than simply fetching out a solicited piece of information from some storage place. Take, for example, the following episode recounted by Nickerson (1981):

> Consider the following effort to recall the name of a street that is located a few blocks from where I live. The name would not come to mind, but I did know it to be the name of a friend. The name Elliott suggested itself, but did not seem to be correct. I thought the name I was looking for was a first name, and although Elliott can be either a first or last name, it is in fact the last name of a friend of mine. I also was fairly sure the sought-for name was the first name of a female, and the Elliot in mind was a male . . . As the search continued, the name Cellier surfaced, the last name of a close friend of Elliott's, who was also a friend of mine. Next came Emil, the first name of Cellier; then Hilda, wife of Emil. Hilda was immediately recognized as the name of the street, (p. 79)

Similar experiences of wandering through the paths of one's memory in search for some longed-for record are not uncommon, and many have been reported in some detail in the literature. These reports suggest that in real-life situations, retrieval often involves a complex interplay between two types of processes (see Jacoby, 1991; Moscovitch, 1989), a controlled, strategic process that guides retrieval, coordinating between different operations directed toward the recovery of the elusive memory target, and the automatic, involuntary emergence into consciousness of ideas and associations throughout the search. Sometimes the controlled process will seize onto these ideas and use them as stepping stones on the way to the sought-after target. At other times they may be recognized as misleading "interlopers" and effort will be exerted to oppose their interfering influence (Jones, 1989).

This interplay between top-down and bottom-up processes derives from the fact that there is hardly ever a cognitive algorithm that can safely lead from a retrieval description (e.g., "what is the name of that street") to its resolution—the memory target (e.g., "Hilda"). Therefore, while retrieval may begin with a controlled, goal-oriented search that takes off from the retrieval description, it must also be receptive to activations and associations that emerge during the search. In his analysis of problem solving, Duncker (1945) discussed this interplay in terms of the idea that the solution to a problem involves the matching of suggestions from above with suggestions coming from below. In fact, his definition of a problem aptly describes the situation in which retrieval is called for: "A problem arises when a living creature has a goal but does not know how that goal is to be reached" (p. 1).

The problem-solving character of remembering can be seen in many everyday memory tasks that tax memory, such as answering questions about course material or retrieving episodes from the distant past (see Burgess & Shallice, 1996; Reiser, Black, & Abelson, 1985). Williams and Hollan (1981), in fact, proposed a jigsaw puzzle metaphor of remembering, in which one begins with starter pieces (specified by the memory query), and by focusing on some section of the puzzle, searches for a piece that may fit, and then verifies that it indeed does.The problem-solving character of remembering makes extensive use of working memory (see e.g., Conway, 1992) in controlling the operation of several processes, coordinating between them, holding the outcome in a temporary store, and orchestrating the entire process.

Different components of the retrieval process are suggested by experimental studies as well as naturalistic studies in which subjects were asked to think aloud in the course of remembering. They are discussed in what follows.

The Importance of the Instigating Conditions

In everyday life we are generally unaware of using our memory. When walking in a familiar neighborhood, we must be constantly con-

suiting our memory of the geographic layout to find our way, but we are hardly aware of doing so. We may become aware of using our memory when we lose our orientation, or when someone we meet asks us for directions. It is in those cases that we deliberately probe our memory for the needed information.

It is important to distinguish between two types of situations that motivate remembering. In the first, retrieval is prompted by a specific question posed by an external agent". Typical examples are a course examination, a job interview, or a police interrogation. Importantly, this type of situation is characteristic of practically all memory studies because in these studies the memory questions are presented and formulated by the experimenter. When remembering occurs in response to externally presented specific questions, it tends to be deliberate and relatively focused and restricted (see Bekerian & Dritschel, 1992).

The second type, which is more typical of naturalistic situations, is when memory queries are generated spontaneously by the person himself, or triggered by accidental encounters or task demands. A simple example was given by Mandler (1980):

> Consider seeing a man on a bus whom you are sure that you have seen before; you "know" him in that sense. Such a recognition is usually followed by a search process asking, in effect, Where could I know him from? Who is he? The search process generates likely contexts (Do I know him from work, is he a movie star, a TV commentator, the milkman?) Eventually, the search may end with the insight, That's the butcher from the supermarket! (pp. 252—253)

This type of situation has hardly any analogue in memory experiments. When retrieval is initiated by the person himself, often in response to task demands or social interaction, the "retrieval description" (Norman & Bobrow, 1979) tends to be loose and ill defined. In other cases still, retrieval may be spontaneous, triggered automatically by some external cues (see Salaman, 1982). Unfortunately, because of the nature of experimental investigation, we know very little about self-generated queries and about automatic retrieval.

Because in everyday life we typically try to retrieve information from memory when we need it, the immediate, instigating conditions may play a critical role in guiding and facilitating retrieval. In fact, in naturalistic situations, the process of remembering has more in common with cued-recall than with free-recall testing. Such is not the case in many institutionalized memory testing situations (e.g., achievement tests, memory experiments), as when a person is required to answer a variety of general-information questions (e.g., Kelley & Lindsay, 1993; Koriat, 1995) that have nothing to do with the immediate goals and circumstances. This contrast helps bring to the fore two related principles of memory. The first is that retrieval depends critically on the presence of retrieval cues, and the second is that retrieval success varies depending on the match between the study and test situations.

The Contribution Retrieval Cues

Tulving (1983) has promoted the notion that memory is a joint product of the stored memory traces and the cues that are present when retrieval is called for. This view implies that given the same conditions of study, retrieval success can vary greatly depending on the conditions of testing. For example, Tulving and Pearlstone (1966) observed that memory for a list of words was considerably better under cued-recall testing, where the cues were the semantic categories to which the words belonged, than under free recall testing. This result supports the importance of the distinction discussed earlier between availability and accessibility, and indicates that information that is not immediately accessible can become accessible when proper cues are present.

In the experiment just described, the cues were presented experimentally. In real-life situations the conditions that instigate retrieval normally provide many useful cues. In externally posed queries, the leading cues can be found in the query itself. Even when these cues are not sufficient to directly trigger the target item, they help delimit the memory regions in which that item is likely to be found.

Retrieval cues are particularly critical for prospective memory—that is, memory to perform intended acts in the future, such as showing up for an appointment or taking a medicine (Brandimonte & Ellis, 1996). What is most important in prospective memory is not the retrieval of the specific content of the to-be-performed act, but the retrieval of the intention to perform it at the appropriate time (Einstein & McDaniel, 1996). To do so, one

must rely on cues that are available in the environment to trigger the intention, devise one's own aids ("the knot in the handkerchief," a timer), or rely on internal cues. Burgess and Shallice (1996) note that the context setting that occurs when a person "sets up" an intention to perform a future action (e.g., to mail a letter) involves a recollection of the context of retrieval (e.g., imagining the journey home, the mailbox), so that the potential cues for retrieving the intention are stored with the intention itself.

Often a failure to perform the planned act stems from the failure to identify the "cue" as a cue for retrieving the intention. Sometimes external cues operate retrospectively, reminding one of a scheduled intention that was missed (e.g., a smell of a burnt cake). Note that some of the cues, like the knot in the handkerchief, carry little information about the content of the act to be performed. Their function is to induce the person to retrieve the intention to perform some act.

Cues differ considerably in their effectiveness in prompting retrieval. In the case of prospective memory, the most effective cues are those that are more distinctive and less familiar (McDaniel & Einstein, 1993). In retrospective memory, in contrast, the effective cues, of course, are those that relate to the content of the solicited item. Research examining the effectiveness of extra-list words in prompting the recall of studied words (Nelson, McKinney, Gee, & Janczura, 1998) indicates that retrieval success varies considerably with a large number of associative properties of the cue and of the target. For example, the larger the number of words that a cue word elicits in word association norms, the lower its effectiveness in facilitating the retrieval of a studied word.

The most effective cues for retrieving an event are personal cues associated with the encoding of that event, because these cues get to be integrated into the memory trace of the event (e.g., Mantyla, 1986). Methods of memory improvement make use of this principle, by having people utilize some system of cues during encoding, which they can latter use to aid retrieval.

How Do Cues Assist Retrieval?

Cues may aid retrieval either through a controlled process in which the person deliberately makes use of them, or through an automatic process in which the cue directly facilitates the emergence into memory of the solicited target (see Neely, 1976). The controlled exploitation of cues is particularly transparent when retrieval is difficult or prolonged. As we shall see below, much of the process of remembering appears then to involve the deliberate use of cues to probe one's memory for additional cues that may bring one closer to the desired target information. The starting point, of course, is the cues present in the situation that drives retrieval. These can be exploited to delimit a context for further search (Koriat & Lieblich, 1974; Norman & Bobrow, 1979).

In parallel, cues may aid retrieval through automatic activations (see Collins & Loftus, 1975; Nelson et al, 1998) emanating from the cognitive context of retrieval, or from the information already recovered. We may try in vain to recall the name of a person, but the name may suddenly pop up the moment we see that person. In fact, this is the way in which many "reminders" operate in everyday life: Passing by a drug store reminds us of a prescription that we have to take. Schank (1982), who considered reminding to be a crucial aspect of human memory, offered an extensive analysis of the type of reminding processes that occur in everyday life.

We know a great deal about automatic activations from experiments on verbal priming (e.g., Collins & Loftus, 1975; Neely & Keefe, 1989) and implicit memory (see Roediger & McDermott, 1994). For example, subjects retrieve faster the answer to a general-information question if that answer has been presented earlier in the context of an unrelated task (Kelley & Lindsay, 1993). In a word-association task subjects are more likely to respond with a word recently studied (e.g., Koriat & Feuerstein, 1976). While such activations generally aid retrieval, they may give rise to inadvertent plagiarism (e.g., Marsh, Landau, & Hicks, 1997) or produce false memories (e.g., Roediger & McDermott, 1995; see Koriat, Goldsmith, & Pansky, in press).

Automatic activations may bring to mind entire scenes or events, as when a certain smell or music conjure up emotionally laden old memories (see Conway, 1992; Salaman, 1982). Such activations might also underlie the recurrence of "flashbacks" memories in people suffering from posttraumatic stress, when memories of the traumatic event intrude into the person's consciousness against his or her will.

The Encoding-Specificity Principle

The importance of the instigating conditions for retrieval is also stressed by the encoding-specificity principle (Tulving & Thomson, 1973), which states that a cue presented during testing will be effective in aiding retrieval to the extent that it has been encoded together with the solicited memory target at study. Thus, a critical condition for effective retrieval is the extent to which the processing that occurs during retrieval reinstates the processing that took place during encoding.

Tulving and Thomson provided some counterintuitive results supporting the encoding specificity principle. For example, the word *hot* is more strongly associated with *cold* than the word *ground,* and indeed, in a free-recall task, *hot* is more effective than *ground* for prompting the recall of *cold.* Nevertheless *ground* will actually act as a better cue for recalling *cold* if *cold* has been originally encoded in the context of *ground.* What is more, when *cold* is encoded in the context of ground, subjects who are successful in recalling *cold* in response to *hot* sometimes fail to recognize it as one that has appeared in the study list! This is like the failure to recognize an acquaintance when we accidentally run into him in a very different context from that in which we are accustomed to see him.

Similar results consistent with the encoding specificity hypothesis have been reported by Morris, Bransford, and Franks (1977). Although memory for words is superior when during encoding subjects attend to the meaning of the words rather than to their sound, the reverse pattern was found when during retrieval subjects were induced to attend to the phonemic properties of the words.

Reinstating the Conditions of Learning during Testing

Retrieval is also affected by the extent to which the testing conditions reinstate the overall conditions of study with regard to the external stimulus conditions (context), the internal state of the person (state), or the person's emotional feelings (mood).

There is evidence that retrieval is context dependent—that is, that memory is best when testing occurs in the same physical environment in which learning took place. For example, Godden and Baddeley (1975) studied the memory of divers when they learned a list of words either on land or underwater and were later tested in the same or in the opposite environment. Recall was better when learning and recall took place in the same environment than in different environments. Subjects have also been found to recall a larger number, of words when they were tested in the same room in which they had studied than when they were tested in a different room (Smith, Glenberg, & Bjork, 1978). It would seem that context-dependent effects are more likely to be found when the environmental contexts differ substantially, and when subjects deliberately associate the studied material with features of the study environment. These effects are obtained only for recall, not for recognition (Eicii, 1965), suggesting uiai oontexLual reinstatement specifically facilitates information retrieval.

A study by Smith (1979) suggests that mental reinstatement of the learning environment may be almost as beneficial for retrieval as actual, physical reinstatement. This idea has been incorporated in the cognitive interview (Fisher & Geiselman, 1992), designed to enhance witness recollection: prior to answering specific questions about a past event, witnesses are instructed to mentally recreate the contextual state that existed at the time of the original event.

Evidence for state dependency comes from findings indicating that memory performance is best when the same internal state is maintained across the learning and testing phases. What subjects learned when drunk they remembered better when drunk than when sober, and vice versa (Goodwin, Powell, Bremer, Hoine, & Stern, 1969). A similar pattern was observed in a study on the effects of marijuana on free recall (Eich, Weingartner, Stillman, & Gillin, 1975). Evidence for state-dependent retrieval is more clearly observed for free recall than for recognition or cued recall (see Eich, 1980). Several studies suggest that retrieval is also mood dependent: memory performance is better when people's moods during study and test match than when they do not (Eich & Metcalfe, 1989).

We now proceed to examine some of the processes that occur during retrieval. As noted, these processes are not easy to trace except when retrieval is effortful and extended over some period of time. Before focusing on effortful retrieval, however, we shall discuss briefly effortless retrieval.

Effortless Retrieval

Not every memory search is laborious; in many cases the solicited information will come to mind immediately (see Nickerson, 1981). The retrieval of well-practiced, well-rehearsed information often has the character of habits or stimulus-response associations.

What makes retrieval automatic? First, there is the case of incidental remembering. Automatic activations may increase the accessibility of a memory entry to the extent that it can emerge into consciousness spontaneously. Such activations have been studied extensively in connection with implicit memory. Second, as far as intentional retrieval is concerned, it would seem that practice retrieving an item from memory is what makes retrieval of that item more automatic (see Bjork & Bjork, 1992). Thus, although we know the numbers from 1 to 10 "by heart," their retrieval is more effortful when we have to list them from 10 to 1. Counting forward is a much more practiced habit than counting backwards.

Let us now focus on effortful retrieval. When memory retrieval is effortful and prolonged, complex regulatory processes of monitoring and control operate in guiding the search.

Preliminary Monitoring and Choice of Mode of Attack

When we are presented with a memory question we do not immediately proceed to answer it, unless the answer pops instantaneously into our head. Rather, in many cases a preliminary monitoring stage exists in which we make a rough assessment about the availability of the answer in memory and the effort needed to access it.

The initial feeling of knowing (FOK) associated with a question is apparently based on a process that monitors the overall familiarity of the question (Nhouyvanisvong & Reder, 1998; Schwartz & Metcalfe, 1992) and the extent to which it brings some fragmentary clues to mind (Koriat, 1993, 1995). If the question leaves us completely blank, chances are that we would not initiate a deliberate search for the answer. Note, however, that a controlled decision to interrupt search apparently does not prevent automatic activations that may ultimately lead to the solicited target (see Koriat & Lieblich, 1977).

Reder (1987) proposed that the familiarity of a question also affects the general strategy of answering that question. When the familiarity of a question is low, subjects would tend to resort to a plausibility strategy, inferring the answer from a variety of cues, rather than to a direct retrieval strategy. She noted, however, that even when familiarity is high subjects may still respond on the basis of the gist of the question. For example, when asked "How many animals of each kind did Moses take on the Ark?" many subjects reply "two," even though they know that it was Noah who did so (Erikson & Mattson, 1981).

Specifying the Initial Context of Search

When preliminary FOK is high, the next step is to determine the initial context in which the search has to be conducted. This decision is suggested by the verbal protocols of subjects produced in the course of remembering (e.g., Burgess & Shallice, 1996; Norman & Bobrow, 1979; Reiser et al., 1985; Williams & Hollan, 1981). This is analogous to that of choosing under what heading to look for a certain topic in a book, or under what directory a computer file is likely to be stored. For example, in attempting to answer questions about course material, students often begin by deliberating whether the question is "from the textbook" or "from the lecture." Or they may attempt to specify more precisely the relevant chapter in the textbook. When the question requires the retrieval of some autobiographical detail, the person may start by recovering a scene or an episode in which that detail is likely to be found. Duncker (1945) referred to this process as one in which "4:he jacket is sewn to the button" (p. 83).

Memory questions differ considerably in the extent to which they delimit, explicitly or implicitly, an effective search domain. Consider the type of questions that specify a particular memory entry to be retrieved—for example, a word or a name. This type of questions, designated "memory pointers" by Koriat and Lieblich (1977), have been extensively used in studies of the tip-of-the-tongue (TOT) and FOK states in which the person initially fails to retrieve the solicited target from memory (Brown & McNeill, 1966; Nelson & Narens, 1990). Such pointers differ widely in the extent to which they offer a plan for search. For example, a question such as "what biblical

character allegedly lived 969 years?" is likely to activate a more useful search domain ("biblical characters") than the comparable question "Which person allegedly lived 969 years?" The delimitation of a search domain is useful not only for memory but also for metamemory: it contributes to the accuracy of the initial FOK associated with the memory pointer (Koriat & Lieblich, 1977). The most effective pointers are those that cast the specification of the solicited target in a format that simultaneously constitutes an effective plan for search. There are different strategies for specifying an initial context for search. For example, one of the strategies used for retrieval of the names of old classmates (Williams & Santos-Williams, 1980) was the location strategy: the subject searches a mental map where target items are likely to be recalled. Reiser, Black, and Kalamarides (1986) also identified several strategies in the retrieval of specific autobiographical events, which they classified into those involving finding a context, and those involving searching within a context. Impairments in the ability to generate a focused contextual description of the sought after information has been seen to underlie some of the memory errors encountered among brain damaged patients (Schacter, Norman, & Koutstaal, 1998).

Access to Partial Information and Zooming in on a Memory Target

Many observations suggest that retrieval is not an all-or-none matter. When we fail to retrieve a word or a name, we may still be able to access some of its fragments or attributes. These can sometimes provide the initial lead for retrieval. The utilization of such partial clues is nicely illustrated by the example presented at the beginning of this chapter, of searching for the name of a street. The partial clues available to Nickerson appeared to shape the entire remembering process. The remembering process sometimes looks as if the rememberer grasps the thread provided by the initial clues and follows their course as they gradually unfold.

Williams and Hollan (1981), discussing the processes involved in recalling the names of classmates, argued that a great deal of the process can be seen as a reconstruction from a variety of bits and pieces of information. They considered partial retrieval to be the central principle that constraints and determines the shape of the reconstructive retrieval process.

Some of the characteristics of partial retrieval are revealed in studies of the TOT state (see Brown, 1991). People in a TOT state are able to provide correct guesses about the number of syllables in the word they are grappling for, some of its letters, and the location of primary stress (Brown & McNeill, 1966). Subjects can also access semantic and associative aspects of the elusive word, such as whether it has a good or bad connotation (Koriat, 1993; Schacter & Worling, 1985).

The partial information initially retrieved provides a lead to a deliberate search, but it also affects the search through its automatic, implicit influence. This is suggested by findings such as that of Durso and Shore (1991): subjects can distinguish between correct and incorrect uses of rare English words even when they classify them as nonwords, suggesting that available partial clues can implicitly affect choice of response. Also, in Koriat's study (1993), when subjects responded with an incorrect word in cued recall, that word tended to have the same connotative meaning as the correct word that they failed to retrieve.

There are indications that during forgetting the more specific aspects of the encoded information are lost before the general attributes (Ceraso, 1987). This implies that generic information is accessible long after the more detailed, item-specific information has ceased to be accessible. Thus, studies of the long-term retention of course material suggest that memory for higher level, superordinate information declines less rapidly than memory for specific details (e.g., Cohen, Stanhope, & Conway, 1992). Similarly, categorical or gist information is lost less rapidly than item information (e.g., Dorfman & Mandler, 1994; see also Brainerd & Reyna, 1993): a person might remember that there was a bird on the list without recalling which bird it was. Such superordinate information may help define an initial domain for search.

The TOT state discloses some further features of retrieval. It has been proposed that a cursory analysis of a memory pointer activates a relatively broad region of memory that includes the target proper but also other entries that satisfy the retrieval description only grossly (Koriat & Lieblich, 1977). The activations emanating from the neighboring memory entries exert two conflicting effects: they interfere with accessing the correct target but at the

same time enhance the subjective feeling that the target is about to emerge into consciousness (Koriat, 1998; Schwartz & Smith, 1997). Several researchers have proposed that the difficult retrieval that is characteristic of the TOT state results precisely from the interfering effect of neighboring targets, and that these compelling but wrong candidates must be first suppressed before the correct target can be retrieved (Jones, 1989).

Indeed, there is evidence suggesting that when a target item is retrieved from memory, neighboring targets are concurrently inhibited (see Dagenbach & Carr, 1994). Dagenbach, Carr, and Barnhardt (1990) found that the failure to retrieve the meaning of a word results in inhibitory priming of semantically related words. Anderson, Bjork, and Bjork (1994) observed that practice retrieving a target item from memory renders related items less accessible. The more likely were these items to interfere with the retrieval of the target item, the more they suffered from practice retrieving it.

In sum, when people fail to retrieve a memory target, they may access partial clues about it, and these can help in guiding the retrieval process. Because retrieval of the general attributes of items precedes the recovery of more specific features, retrieval sometimes looks like an attempt to close in on the target through a progressive narrowing of its description (Kolodner, 1983; Koriat & Lieblich, 1974). During this process competing memory candidates are suppressed to allow zooming in on the target.

Probing One's Memory during Retrieval

How is partial information utilized in the course of remembering? Several observations highlight the importance of self-cueing during retrieval—that is, of cognitive operations whose immediate aim is the recovery of further cues that can lead to more refined cues, and ultimately to the target itself.

How are additional clues recovered? Several studies concur in identifying a recursive pattern that occurs in the course of arduous remembering: a memory environment is specified in which a search is to be conducted, that environment is searched for additional clues, and the information retrieved is evaluated. This cycle is repeated, gradually refining the description of the information to be searched, until the search closes in on the target. For example, Williams and Hollan (1981) noted that in attempting to retrieve the names of high school classmates, subjects produced an enormous amount of information that was incidental to the task of recalling the names, including details about the school, about where people lived, and so forth. Examination of this information suggests that its main function was to probe one's memory for additional clues that can better specify a new context for search. They proposed that remembering consists of a series of "kernel retrieval" processes, each including three stages: a context is retrieved (e.g., the volley tennis group), a search is conducted within that context, and the information recovered is verified.

Reiser and his associates (Reiser et al., 1985, 1986), who studied recall of autobiographical episodes, also emphasized that one memory retrieval can be undertaken in order to provide cues for a subsequent retrieval. According to their context-plus-index model, specific personal episodes are recalled by first recovering the general context in which they were likely to have been encoded, and then specifying the features that uniquely distinguish these experiences from others in that context. They proposed that scripts (e.g., "eating in restaurants," see Schank, 1982) typically serve as convenient retrieval contexts. Burgess and Shallice (1996), too, noted that subjects did not always retrieve the target memory record directly, but sometimes recovered a useful cue first. Thus, it was not uncommon for subjects to answer the question "what was the weather like yesterday morning" by crying to remember first what they were wearing.

Similar processes seem to take place in retrieving information from semantic memory. One of the best-studied tasks in memory research is that of retrieving the members of natural categories such as vegetables, furniture, and the like (Raaijmakers & Shiffrin, 1981). A study by Walker and Kintsch (1985) suggests that even in this task retrieval relies on the recovery of contexts in which a search is conducted. Verbal protocols suggested a series of two-stage cycles: generating a context in which category members are likely to be found, and then using that context as a retrieval cue to produce the category members themselves. Importantly, most of the contexts generated were episodic rather than abstract-semantic (e.g., in searching for automobiles, one may picture a parking lot, the cars in front of the dorm, etc.).

The Strategic Regulation of Memory Retrieval

In the previous sections we discussed some of the recurrent processes in prolonged retrieval. Examination of the overall regulation of remembering, however, brings to the fore a variety of operations that are not specific to memory, but fall within the domain of higher order, executive-supervisory functions. These operations are involved in the overall regulation of the remembering process, and are so intertwined with lower level memory processes that it is difficult to understand remembering without considering their indispensable role. Unfortunately, little systematic work exists regarding the overall regulation of the remembering process.

An act of remembering often has the character of a goal-oriented process that is controlled and guided by an overriding program (see the example from Nickerson, cited earlier). This supervisory program is responsible for choosing a starting point, recruiting a strategy, monitoring its execution, and changing it when it proves unsuccessful. Thus, remembering may involve a complex set of problem-solving routines that are interlaced with processes concerned with memory retrieval proper (Burgess & Shallice, 1996).

Discussing the global structure of a remembering act, Norman and Bobrow (1979; see also Morton, Hammersley, & Bekerian, 1985) identified three general stages: specification of the information needed (and hence of the verification criteria), a matching process in which memory records are accessed and compared with the target description, and evaluation of suitability of the recovered records (see also Conway, 1992). Each of these stages calls for a variety of monitoring and control operations.

Burgess and Shallice (1996) reached similar conclusions regarding the broad structure of the prototypical retrieval process. However, their analysis suggested a more complex organization in which layers of control lie between general problem solving and specific memory retrieval, with monitoring running parallel with the different stages of the process. An important feature of their scheme is that the supervisory processes of monitoring and control are assumed to run parallel with the different stages of remembering rather than being confined to any one stage.

While there is agreement regarding the controlled, goal-oriented nature of retrieval, the role of "suggestions from below" has also been acknowledged. Often spurious activations lead the search astray. Williams and Santos-Williams (1980) noted that subjects sometimes abandon one strategy in response to the retrieval of information that appears to be particularly useful in the context of a different strategy. Furthermore, verbal protocols disclose moments in which the person seems to deliberately relinquish strategic control altogether, adopting a passive-receptive attitude. Nickerson (1981) noted that in retrieving words from lists, subjects often begin with a passive attitude, and then switch to an active, systematic search when the passive approach no longer yields a satisfactory return (see also Walker & Kintsch, 1985). Koriat and Melkman (1987) observed a similar pattern, but also diverted, the retrieval of words from a list becomes less controlled, moving along associative links between the words rather than along conceptual-logical relations.

The Strategic Regulation of Memory Reporting

We turn now to the final stages of the process, those involved either in selecting an answer and providing it, or in reporting "I don't know."

Consider first cases in which the person fails to provide any answer. A fast "don't know" response may be issued based on the assessment that the needed information is unavailable in memory. Examination of the latency of "don't know" responses suggests that such responses are not simply a result of scanning one's memory and failing to find the appropriate target, but actually depend on rather complex processes (see Glucksberg & McCloskey, 1981; Klin, Guzman, & Levine, 1997).

Even after initiating a memory search, a person may abort the process if the search fails to produce the solicited target. It should be noted that when the preliminary FOK associated with a question is high, subjects spend more time searching for the target before giving up than when initial FOK is low (Nelson & Narens, 1990). The decision to continue searching reflects the operation of two conflicting tendencies: the reward for finding the correct answer, and the cost for spending time searching (Barnes, Nelson, Dunlosky, Mazzoni, & Narens, 1999).

What are the processes underlying the outputting of an answer? All of the retrieval models reviewed earlier incorporate verification processes in which the memory records recovered are evaluated for suitability. These processes occur throughout the retrieval process, often leading to self-corrections. Burgess and Shallice (1996] stressed the frequent occurrence of "errors" in verbal protocols, which would normally not show up in the final response reported because they are corrected or edited out. They proposed that these might provide the key for explaining the occurrence of confabulations among patients with frontal lobe damage (see also Moscovitch, 1989). According to them, memory errors are a standard part of the normal memory retrieval so that mechanisms that guard against them must exist.

Williams and Hollan's study (1981) of the memory for classmates also revealed a considerable number of "fabrications" (about a third of the total number of names reported), some of which were later corrected by the subject. Walker and Kintsch (1985) examined a different kind of error: reporting a category member that has already been reported. Whereas subjects who were asked to think aloud produced i large number of such "errors," control subjects produced practically none, suggesting that they were able to edit out retrieved but already reported items.

Editing processes are particularly important when the accuracy of what one reports is at stake. A person on a witness stand, for example, must be concerned not only with "telling the whole truth" but also with telling "nothing but the truth." In order to meet both requirements, an eyewitness must monitor the correctness of the information that comes to mind and weigh the costs of providing a piece if information that may be incorrect against he costs of withholding a correct piece of information.

Koriat and Goldsmith (1994, 1996) examined the strategic regulation of memory reporting within the traditional, item-based memory assessment framework. Memory quantity was defined as the likelihood of remembering an input item, whereas memory accuracy was defined as the likelihood that a reported item is correct. Their results suggested that the option f free report—that is, the option to decide which items to volunteer and which to with-old, allows subjects to enhance their memory accuracy at the expense of memory quantity by screening out items that are likely to be wrong. This was true for both recall and recognition memory testing. How do people regulate their memory accuracy? According to a model proposed by Koriat and Goldsmith (1996), when recounting past events, people monitor the likelihood that each item of information that comes to mind is correct. They then apply a control threshold to the monitoring output for the item with the highest subjective probability of being correct. The item will be reported if its assessed probability passes threshold, and will be withheld otherwise. The setting of the control threshold depends on the relative utility of providing complete versus accurate information: the stronger the motivation for accuracy, the more selective people are in their reporting, and hence the higher the level of memory accuracy attained. Several experiments provided support for the model, revealing the manner in which monitoring and control processes mediate between memory retrieval on the one hand and memory performance on the other. A quantity-accuracy tradeoff was observed: subjects could achieve a higher level of memory accuracy only by withholding a larger number of correct answers as well. The degree of tradeoff, however, varied strongly with monitoring effectiveness—that is, the ability to distinguish between correct and incorrect answers. Effective monitoring allowed a person to achieve a higher level of memory accuracy at a smaller cost in quantity.

Another means by which subjects can regulate the accuracy of their memory reports is by controlling the "grain" or level of generality of the reported information (see Goldsmith & Koriat, 1999). Rather than withhold an answer entirely, a person may choose a level of generality at which he is less likely to be wrong (e.g., "in the early afternoon" rather than "at 2 P.M."). The choice of grain size is guided by the attempt to compromise between the tendency to be accurate and the tendency to be informative (Goldsmith & Koriat, 1999; Yaniv & Foster, 1995).

In sum, in this chapter we focused on control processes in remembering. Some of these processes undoubtedly take place in simple, laboratory contexts, but most of them are more clearly apparent in the everyday use of memory retrieval, particularly when retrieval is more laborious. A greater effort is being made in recent years to bring some of these processes under systematic experimental investigation.

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