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8 Elaboration and Distinctiveness in Episodic Memory

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INTRODUCTION

In keeping with the general theme of the Uppsala Conference on Memory, this chapter gives a broad overview of our current ideas about human memory and related processes. The ideas stem more or less from the "levels of processing" view of memory advanced by Craik and Lockhart (1972). More directly, however, the present views develop the notions discussed by Lockhart, Craik, and Jacoby (1976) and by Jacoby and Craik (1978).

The chapter gives our views on some factors that we believe to be necessary for an adequate description of human memory at a behavioral level. Our description is in terms of hypothesized processes, and it is a *cognitive* view in that it stresses necessary interactions among attention, perception, memory, comprehension, and action. We argue that memory is not a separate entity but is one aspect of the total system. That is, the basic tasks of cognition are to comprehend and to formulate appropriate actions; memory is viewed as the record of the perceptual-motor operations carried out throughout the behavioral sequence. Such a view is inimical to an understanding of cognitive processes in terms of a succession of independent stages; rather, we endorse the arguments of Rumelhart (1977) and others for an interactive system in which sensory and semantic aspects of processing influence each other during perceptual and conceptual analysis. In light of this approach to the study of cognitive processes, it may not be profitable to dissect cognition into a series of stages, to attempt to understand each stage in isolation, and then finally to assemble the stages into an overall view. The "interactive" viewpoint suggests rather that a fuller understanding may be achieved by first formulating an

adequate broad characterization of the system and then by refining that description through experiments. This latter strategy is exemplified by the present approach.

One further general theme running through the chapter is the contrast between dichotomies and continuities in descriptions of information processing. As descriptions of cognition become more sophisticated, it is undoubtedly useful to highlight new concepts by framing them as black-or-white alternatives. In most cases, however, as the concepts become familiar, it seems more useful to treat such factors as continuous processes—with one processing mode shading off into another—rather than to insist on the original "either-or" formulation (Newell, 1974). We believe that *some* discontinuities may play a useful theoretical role (for example, discontinuities obviously exist between input modalities and may exist between primary and secondary memory; Craik & Levy, 1976), but in general it seems necessary to move from dichotomies to continuities and their interactions as our understanding grows. Arguments for continuities are given throughout the chapter.

In the following sections, the processes of attention, rehearsal, and encoding are examined; and the distinctions between encoding and retrieval, between episodic and semantic memory, and between memory as stage setting versus memory viewed as a system of traces are discussed in the framework of a processing view of cognition.

ATTENTION

A major controversy in theoretical descriptions of selective attention has concerned the locus of selection in the flow of information through the organism. In Broadbent's (1958) theory, wanted stimuli were selected for further processing quite early in the processing sequence. For classes of stimuli defined physically, this posed no problem; but the theory had some difficulty explaining how semantically relevant stimuli on unattended channels captured attention and conscious awareness. The problem was solved in two different ways. Treisman (1964) modified Broadbent's original filter theory by suggesting that stimuli were subjected to successive levels of analysis and that the level reached by a particular stimulus depended both on physical characteristics of the stimulus and on current biases and expectations existing in the analyzing system. Treisman's modifications were endorsed by Broadbent (1971) in later versions of his model. Despite the role played by semantic factors, the Treisman–Broadbent theory is still an "early selection" model because unattended stimuli are analyzed in terms of their physical features only; typically, they do not proceed to semantic levels of analysis.

The second class of solutions to the problem of semantic analysis involves the suggestion that all incoming stimuli are fully analyzed for meaning and that only after this full analysis are the most important stimuli selected for further processing and for conscious awareness. Such "late selection" models were put forward by Deutsch and Deutsch (1963) and by Norman (1968), among others.

However, several recent theorists have rejected the either/or dichotomy of early versus late selection theories and suggested instead that selectivity takes place throughout the continuum of processing. For example, Erdelyi (1974) postulated that "selectivity is pervasive throughout the cognitive continuum, from input to output [p. 12]." Erdelyi also quotes from Kafka's *The Trial*: "The verdict is not suddenly arrived at, the proceedings only gradually merge into the verdict [p. 1]." In a sense, the verdict is a summary of the proceedings but at a different level of description; in other words, the verdict prescribes appropriate action on the basis of the evidence. Similarly, in cognition, the action taken subsequent to analysis of a stimulus sequence "summarizes" the analytic proceedings. However, in the legal example, records of the court proceedings exist as well as the trial's outcome, and these records may be re-examined later. Again, this is analogous to information processing in our view—that is, cognitive analysis is constrained by procedural rules; it leads to appropriate action and leaves a record of the analytic operations performed throughout the proceedings.

If selectivity takes place throughout processing, what factors determine selection or rejection for particular stimuli? In his notions of stimulus set and response set, Broadbent (1971) essentially suggested that the system could adopt either an early or a late selection mode, depending on the task. For example, if the wanted stimuli are defined physically (e.g., red letters among a mixed array of red and black letters), then "stimulus set" conditions hold, and the targets can be picked out without full analysis of all stimuli. On the other hand, if targets and nontargets do not differ physically (e.g., digits from an array of digits and letters), then "response set" conditions hold, and all stimuli must be analyzed to the level where they are identified as letters or digits.

This line of thinking has been extended by Erdelyi (1974), Keren (1976), and Johnston and Heinz (1976), although these later workers have stressed the continuity of processing and selection rather than the notion of two processing modes. The basic idea is that analysis proceeds along the early–late continuum as far as is necessary to decide whether the stimulus is wanted or not. The amount of processing is thus very much determined by the current task—including both stimulus aspects and aspects contributed by the organism. In the first category, salient stimuli and stimuli that are highly compatible with the analyzing system (e.g., common words and pictures) will receive greater amounts of processing; and in the second category, processing will be modified depending, for example, on whether the subject is

proofreading or reading for meaning. By the present view, memory is a record of the processing carried out, and the memory trace will thus reflect both the amount and the qualitative nature of the analyses originally performed. If the perceptual processing necessitated a description of the stimulus in semantic terms, then the memory record will also reflect these semantic qualities. In an effort to relate the qualitative nature of processing to retention, Craik and Lockhart (1972) postulated that stimuli processed to "deeper" semantic levels were associated with higher levels of retention in a subsequent memory task.

The interplay of attentional and memory factors is nicely illustrated in a study by Johnston and Heinz (1976). In the relevant experimental conditions, two lists of words were presented binaurally; subjects were required to shadow the target list, which in one condition was defined physically (words spoken in a male voice, whereas nontarget words were spoken in a female voice) and in a second condition was defined semantically (e.g., animal names as opposed to male first names). In addition to the shadowing task, subjects performed a reaction-time task—they pushed a button in response to a light signal that occurred randomly throughout the shadowing trials. It was argued that reaction time (RT) indexed the amount of residual processing capacity left from the shadowing task; the more attentional capacity consumed by shadowing, the longer the RT. Finally, a recall test was given for the rejected words. The results showed that shadowing was more accurate and RTs to the light signal shorter under early selection conditions—that is, where subjects could select target words by voice quality. Thus, in general, early selection is easier and consumes less processing capacity. However, in the later retention test, it was found that memory for nonshadowed words was superior under late selection conditions—that is, where a semantic analysis was necessary. Finally, in one experiment, nonshadowed words were repeated, and it was found that repetition was associated with larger increments in recall under semantic-selection conditions.

The Johnston and Heinz (1976) results demonstrate the flexibility of attention; the authors reject the early-late dichotomy in favor of a processing continuum. They conclude that as the task necessitates "later" semantic analysis, more attentional capacity is required but also that memory for all stimuli is enhanced. One result that at first sight raises a problem for the notion that semantic analysis is associated with high levels of retention is the finding by Potter (1975) that when subjects monitor a rapidly presented sequence of pictures for a previously described target picture, subsequent recognition memory for nontarget pictures is rather poor. Because the targets are described in semantic rather than physical terms (e.g., "a boy fishing"), it seems that all pictures must be processed semantically and thus that they should be well remembered. However, this argument assumes that semantic analysis is all-or-none, and this is surely untrue; a picture can be rejected as

not being of a boy fishing without a very extensive analysis of what it *is*. Analysis presumably proceeds from global to more specific features until a sufficient number of critical characteristics of the target are either confirmed or violated. If a picture can be rejected after a very general, cursory analysis, then memory for the picture will be correspondingly poor.

A further example of flexible processing and its consequences for memory, is Kolers' (1975) observation that increased skill at a difficult reading task (and presumably less extensive analysis of the material) is associated with poorer retention of the material read. The Kolers result shows that memory is not a simple function of how early or late the processing was or of the depth of processing reached but that extensiveness of processing (degree of elaboration) is also of primary importance. It seems preferable to characterize stimulus analysis not as an unvarying sequence of stages with processing stopped at a certain level, but rather as a process in which a variety of possible operations are weighted differentially depending on stimulus characteristics, task demands, and the subject's degree of skill.

REHEARSAL

The question addressed in this section is whether the effects of repetition on memory and learning differ systematically as a function of the mental operations involved in the repetition. The distinction between two types of rehearsal—maintenance and elaborative processing—has been made by several writers (Craik & Lockhart, 1972; Jacoby, 1973a; Mandler, 1978; Woodward, Bjork, & Jongeward, 1973). Although these various authors used different descriptive terms, the central distinction is similar in all cases—namely, that one function of rehearsal is to maintain items in conscious awareness for ready access and that a second function is to perform further cognitive operations on the items to enhance their later memorability. Craik and Lockhart (1972) made the rather extreme suggestion that maintenance rehearsal had *no* beneficial effects on subsequent retention, because memory was held to be a function of depth of processing and in maintenance rehearsal the subject was apparently repeating operations at a depth already attained. This prediction has been confirmed by some authors for recall (Craik & Watkins, 1973; Jacoby, 1973a; Woodward et al., 1973); but when retention is measured by recogntiion, maintenance rehearsal is typically associated with increments in performance (Glenberg, Smith, & Green, 1977; Woodward et al., 1973). Thus apparently Craik and Lockhart's suggested dichotomy between two sets of effects was too simple.

With regard to recognition, Glenberg et al. (1977) have suggested that maintenance rehearsal enhances performance by the addition of frequency or

context tags to the item's representation and that these tags facilitate discrimination of old from new items in a subsequent recognition test. Mandler (Chapter 14, this volume) discusses the same issues; he agrees with the empirical outcome but attributes the beneficial effects of maintenance processing to increased integration or coherence of the item.

In at least two studies, beneficial effects of maintenance processing on recall have also been reported (Dark & Loftus, 1976; Darley & Glass, 1975). The reasons for the discrepancy between these studies and experiments showing no effects on recall are not immediately obvious; but in one study (Darley & Glass, 1975), subjects had to compare the maintained item with a succession of other items, so clearly the subject was performing more than simple maintenance operations. Dark and Loftus (1976) presented three or five words at a rapid (1-sec) rate before the retention interval; it seems very possible that the presentation rate left little time for elaborative processing of the word string during presentation and that again subjects did more than maintain items during the subsequent rehearsal interval. However, both sets of authors agree with the present analysis that final retention depends on the operations performed during the rehearsal interval rather than on the number of repetitions per se. Thus Dark and Loftus suggest that overt rehearsal may show maintenance or elaborative properties in different situations; also, both they and Darley and Glass suggest that rehearsal will increase in effectiveness to the extent that attention is involved.

A related issue concerns the relative effectiveness of repetitions at different levels of processing. The results of Johnston and Heinz's experiment described earlier suggest that the effect of repetitions interacts with depth in the sense that repetitions of an item are associated with greater increments in retention performance at greater depths of encoding. For example, if an item is encoded semantically, repetition will have more effect than if the item is encoded phonemically. This interaction between repetition and depth was also reported by Craik and Tulving (1975, Exps. 3 & 4), by Jacoby, Bartz, and Evans (1978), and by Anderson and Reder (1978). On the other hand, both Nelson (1977) and Chabot, Miller, and Juola (1976) reported no interaction between repetition and depth of processing; the reasons underlying this discrepancy are unclear at present.

Nelson (1977) has objected that the finding of an effect of repetition on recall by Craik and Tulving (1975) and others contradicts the notion that maintenance processing has no effect on later recall, because in these experiments items were processed at the same level on each of two presentations. It must be agreed that repetitions do enhance recall even in situations where the item is subjected to the same qualitative type of processing on successive trials, and in this sense Craik and Lockhart's (1972) original suggestion regarding Type I processing (that repetition must lead to

deeper processing before retention is improved) is disconfirmed. However, a distinction should perhaps be made between *maintenance processing*—where subjects maintain an item continuously in mind by rehearsal—and explicit *repetitions* of the same nominal item—in some cases after quite lengthy intervals. In the former case, it is likely that the subject indulges in little new processing on each successive rehearsal cycle; but in the latter case, it is probable that the item is treated somewhat differently on successive presentations, especially if the presentations are spaced (Jacoby & Craik, 1978). In addition, spaced presentations may involve spontaneous retrieval of the previous encoding of that item, and this too may augment recall (Lockhart, 1973). Thus there may be little conflict between the cases reported by Nelson in which repetition of an item is associated with enhanced recall and the suggestion discussed earlier that "pure" maintenance rehearsal has essentially no beneficial effect on recall. It seems quite possible that the effects of massed and spaced practice (e.g., Hintzman, 1974) are attributable to the same processes that underlie maintenance and elaborative processing. This possibility is discussed by Jacoby and Craik (1978).

However, it seems that again a simple dichotomy should yield to a continuity. In this case the distinction between maintenance and elaborative processing should perhaps be replaced by a continuum representing the degree to which repetitions lead to different encodings on successive presentations; to the extent that the existing encoding is elaborated, retention will be enhanced. The question of whether repetitions do or do not interact with the type of processing involved to produce increments in retention must await further empirical and conceptual anlaysis before it can be resolved. One recent suggestion by Anderson and Reder (1978) is that deeper levels of analysis provide much greater scope for elaborative processing; thus repetitions at deeper levels of processing have at least the potential for allowing the formation of rich, elaborate encodings, which in turn enhance the item's memorability. This suggestion, together with the notion of a maintenance-elaborative continuum, leads to a more complex view of rehearsal; namely that the operations performed during rehearsal can vary both in the extent to which they change or remain the same from cycle to cycle (the maintenance-elaborative dimension) and also with regard to the qualitative nature of the operations carried out (depth of processing). Whereas maintenance-processing operations may be performed at any level of processing, truly elaborative processing will only be possible at deeper levels where the potential for richer encoding exists. In any event, it seems clear that the effects of rehearsal on memory will only be understood once we attain a clearer conceptualization of the constituent mental operations and their interactions. Further related ideas on the interaction of repetitions with depth of processing are discussed by Jacoby et al. (1978).

ENCODING

In this section, we discuss the factors we believe to be important for effective encoding in memory; in the next, the interactions between encoding and retrieval processes are discussed. The factors discussed in the previous two sections under the headings *Attention* and *Rehearsal* are clearly also relevant to the encoding problem. Formation of an elaborated encoding involves extensive or elaborative processing and consumes more attentional capacity (Johnston & Heinz, 1976). Following Bower (1967), Craik and Lockhart (1972), and others, it is argued that the memory trace reflects those operations performed at input for the primary purposes of perception and comprehension. In overview, our position is that elaboration of the perceived event leads to the formation of a distinctive encoding; in turn, this distinctiveness facilitates specification of the wanted encoding at retrieval. This point of view is discussed more fully by Jacoby and Craik (1978); here we restrict ourselves to commenting on several questions that might be asked about such a view. We should also mention that many of the arguments advanced here are similar, at least in part, to the views of other workers (e.g., Eysenck, 1978; Klein & Saltz, 1976; Kolers, 1975; Lockhart, Craik, & Jacoby, 1976; Moscovitch & Craik, 1976; Norman & Bobrow, 1977; Wickelgren, 1977).

What is the relation between elaboration and depth (or type) of processing? We argue that extensive processing of shallow (i.e., sensory) information will not usually benefit later memory performance. For example, prolonged study of complex but meaningless patterns is not associated with good recognition of the patterns (Goldstein & Chance, 1971), whereas very brief exposures of meaningful pictures is associated with high levels of later recognition memory (Potter, 1975). However, it would be wrong to conclude that "sensory" processing inevitably leads to poor memory; experience in discriminating one person's voice from others or in tasting wines or in differentiating samples of handwriting can all lead to excellent memory for a particular pattern. In these cases, the sensory surface features of the stimulus have become rich and meaningful through the gradual build-up of a cognitive structure to differentiate subtly different stimuli (Gibson & Gibson, 1955). In this sense the sensory/semantic distinction is also a continuum rather than a dichotomy. A further correlate of depth is the degree of organization of the system; it is postulated that deeper, more meaningful structures are more highly articulated and thus afford greater possibilities for reconstructive retrieval.

Thus greater depth of processing is characterized by qualitative differences (greater meaningfulness), by a greater number of possible elaborations, and thus, typically, by richer descriptions and more distinctive encodings of events. However, this description of depth is clearly vague; as Nelson (1977) and others have pointed out, it would be far preferable to have an index of depth independent of retention level. Are we any nearer to achieving an independent index of depth? Processing time often correlates with depth defined intuitively, but this relation is not a necessary one; complex, shallow encodings take a long time to achieve but are not well remembered (Craik & Tulving, 1975, Exp. 5).

Residual processing capacity is another possibility; if deep encodings consume more attentional capacity, less will be left to perform a second, concurrent task. Johnston and Heinz's (1976) results, described earlier, are in line with this supposition, as are results of an unpublished study by E. Simon and F. I. M. Craik. In the latter experiment, subjects monitored a rapidly presented series of visual words for target words defined either structurally, by rhyme, or by semantic category; at the same time, a series of seven pairs of digits was presented auditorily, followed by a probe pair for recognition. (The subject's task was to decide whether the probe pair was a member of the series just presented.) The results showed that auditory recognition performance declined as a function of the depth of processing required by the visual monitoring; also, in a subsequent recognition test for the visually presented words, recognition levels were highest for words processed semantically. Although at present, concurrent processing capacity offers a possible way to measure depth, further work must establish the limits of this relationship. It is possible, for example, that processing capacity, like processing time, may be sensitive to complexity as well as to depth.

It is argued that depth of processing and degree of elaboration combine to yield an encoding of greater or lesser distinctiveness. If distinctiveness is the crucial factor underlying memory performance, it might be asked how this dimension differs from the more traditional dimension of trace strength. In our view, distinctiveness is unlike strength, primarily because distinctiveness is necessarily a relational, rather than an absolute, concept. That is, the distinctiveness of an object or event is always relative to a particular context. Because this is so, it follows that for a distinctively encoded event to be discriminable and distinctive again at retrieval, it must be contrasted with the same contextual items that accompanied the event at encoding. That is, the original encoding context must be reinstated. This line of argument stresses the necessity of taking into account the relationship between encoding and retrieval conditions; this topic is treated in a subsequent section.

What are the effects of practice at encoding a class of events on later memory for the events? Following Kolers (1975), we believe that practice makes encoding easier and more efficient; redundant operations gradually drop out. Thus practice is good for the primary task; but because memory is a positive function of the nature and number of operations performed at encoding, it follows that as practice increases, retention of the encoded events will decrease. Note that these remarks do not apply to practice of a single episodic event but rather to practice of a class of events. The notion is nicely

illustrated by the results reported by Kolers (1975); he had subjects engage in extensive practice at reading samples of transformed text and found that subsequent recognition memory for the passages read declined as subjects became more practiced at the novel reading operations.

Finally, in this section it may be asked whether distinctiveness is the *only* principle necessary for an understanding of memory functioning. Our answer is that other factors are also necessary; two such factors are briefly discussed. First, the compatibility or congruity between the encoded event and other aspects of the encoded context is important—especially those aspects of the context later used as retrieval cues for the event. This point was illustrated by Jacoby and Craik (1978, Exp. I). On each trial, subjects were shown a card that had one word printed on one side (the focus word) and two words printed on the other side. The task was to decide as rapidly as possible which one of the two words on the reverse (the target word) was more closely related to the focus word. The words on the reverse were either high associates, low associates, or unrelated to the focus word and were arranged in various pairings: high–high, low–low, high–unrelated, and so on. In a second phase of the experiment, the focus words were presented as cues for the chosen target word; or the focus words, followed by the target words, were presented for recognition.

It was expected that difficult initial decisions (for example, when both words on the reverse were high associates, both were low associates, or both were unrelated) would necessitate more analytic operations and would thus lead to formation of a more distinctive trace and higher levels of retention. It might also be expected that the a priori relation between focus and target word would also affect the level of cued recall. The results are shown in Fig. 8.1. For cued recall, the strength of associative relationship (high, low, unrelated) is clearly a major determinant of performance, but within each degree of relationship the difficulty of decision also has an effect. For recognition, neither variable affects performance to the same extent. The major point to be taken from this experiment is that the associative relationship between cue and target, as well as the amount of work performed on the event at encoding, are both important determinants of recall.

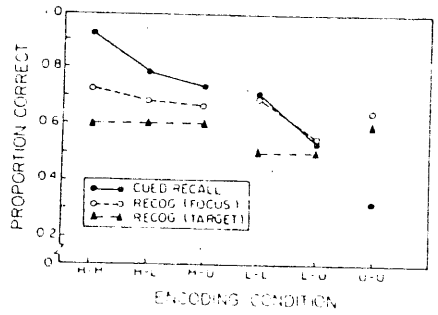

FIG. 8.1 Cued recall and recognition as a function of degree of association between focus and target words. (From Jacoby & Craik, 1978.)

A second and somewhat related factor to be taken into account by any overall theory is the nature of the retrieval test. It seems possible that recall relies more heavily on reconstructive processes than does recognition; if this is so, then an encoded item that is congruent with semantic memory structures should be more easily recalled then one that is not. On the other hand, recognition performance may be less affected by this degree of congruity. A second experiment by Jacoby and Craik (1978) illustrates the point. In this study, subjects were asked about semantic category membership of single words presented briefly. The category question was asked first (e.g., "Is the word an animal name?"); then the word was presented, and the subject decided "yes" or "no" as rapidly as possible. Subjects understood that the experiment was investigating decision latency. Of the 72 trials, 24 led to "no" responses and are not considered further. In the remaining 48 trials, 16 categories from the Battig and Montague norms were used, with three words being drawn from each category. Of the three, one was a high-ranking (common) exemplar, one was drawn from the middle of the normative list, and the third was a relatively uncommon exemplar of the category. It was assumed that subjects would have to carry out more processing before reaching a decision on low-ranking exemplars, and this supposition was borne out by the longer decision latencies associated with low-ranked words. Arguably, this more extensive processing should lead to relatively elaborated, distinctive encodings, which would then be more memorable than high-ranked words. In a second phase of the experiment, subjects were given either a cued-recall test (the category names served as cues) or a recognition test.

The results are shown in Fig. 8.2. Recognition performance was highest for low-ranking exemplars, whereas in cued recall, high-ranking exemplars were associated with the highest retention levels. Jacoby and Craik concluded that although the greater difficulty associated with initial classification of uncommon category members led to formation of a more elaborate encoding—which benefited subsequent recognition—this factor was overridden in cued recall by the greater ease with which relatively common

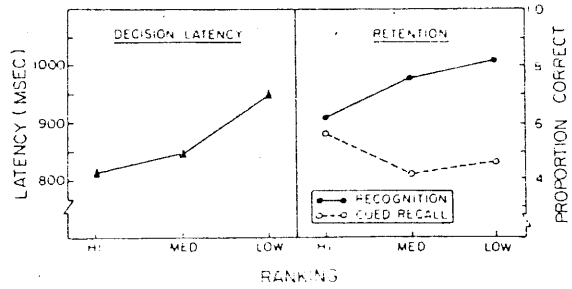

FIG. 8.2 Decision latency, recognition, and cued recall as a function of exemplar ranking. (From Jacoby & Craik, 1978.)

exemplars could be reconstructed from the category name. Again the general conclusion is that whereas trace elaboration and distinctiveness are major determinants of retention, they are not the only factors to be taken into account.

To summarize, we argue that attention, rehearsal, degree of practice, number of repetitions, the extensiveness and qualitative nature of the encoding processes converge to give rise to a memory trace that is more or less distinctive from other traces in the system. By "memory trace" we mean the record of those cognitive operations crried out initially for the purposes of perception, comprehension, and decisions concerning action. Whereas in general, distinctive traces are associated with high levels of retention, other factors—such as the congruity of the target event with the episodic context or with permanent semantic strutures—are also held to be important. Two illustrations of such factors were given, but it should be stressed that the examples are intended to illustrate interactions with other variables rather than to serve as a complete list of relevant factors. The examples showed that it is necessary to take both encoding conditions and retrieval conditions into account before performance can be adequately described; in the following section we put forward some views on the interactions between encoding and retrieval.

ENCODING AND RETRIEVAL

Encoding and retrieval processes have never been viewed strictly as a dichotomy; nevertheless, they have traditionally been regarded as rather separate components of memory. More recently, the work of Tulving and his colleagues has been instrumental in establishing the view that it is the *interaction* between encoding and retrieval, rather than either set of processes taken separately, that is crucial to an understanding of memory performance.

In this section we wish to emphasize the strong similarity between encoding and retrieval; we will argue, in fact, that they are essentially identical processes, although having somewhat different goals. That is, just as at input the stimulus event is processed in certain qualitative and quantitative ways depending on the stimulus, task demands, and so forth, so the information provided at retrieval is processed more or less deeply and elaborately depending on the subject's set, the compatibility of the retrieval cue with the analyzing system, and the demands of the current task as perceived by the subject. At input, encoding operations are carried out and are recorded as a memory trace; it is postulated that the pattern of retrieval operations is automatically matched with such records of past operations and that remembering of a past event occurs when some critical proportion of

operations reflected in the trace is repeated in the current set of operations. Some theorists (e.g., Kolers, 1973; Restle, 1974) have argued that the concept of the memory trace is unnecessary and that remembering is simply a function of repetition of the operations themselves. By this view, familiarity is a function of the degree of skill with which the analyzing operations are performed by the system. Although we concede that such a dynamic view of remembering has much to recommend it over the rather static notion of collections of memory traces, it seems to us that the repetition of operations viewpoint has some trouble in explaining the recall or recognition of specific episodic occurrences. If the original event did not leave a record of its occurrence, what underlies the subject's feelings of recognition on the second presentation? To say that the operations are executed more fluently on the second occurrence hardly seems sufficient, as often the event in question comprises well-known elements (words, faces, objects) in novel patterns or surroundings. What is the correlate of the feeling that the event has occurred previously? Finding no answer to this question, we prefer to say that the operations leave a record and that recognition is a function of how completely the record is matched by operations carried out on the event's second occurrence. Also, successful recognition will depend on the uniqueness or distinctiveness of the target event's encoding; if the encoding record is highly similar to the record of many other past events, then even a high degree of overlap between target information and cue information will not be associated with successful recognition, because a distinctive encoding/retrieval combination cannot be achieved. In metaphorical terms, the retrieval information "resonates" with too many traces for the target trace to be successfully isolated (Lockhart, Craik, & Jacoby, 1976).

What determines how retrieval information is treated? In particular, what determines whether or not the cue is elaborated extensively by the processing system? Some "retrieval encodings" will be formed relatively automatically or spontaneously from the cue, just as stimuli typically induce their "habitual" percept; but other encodings will be formed only in response to task demands. For example, in situations where the subject is aware of having experienced the event previously, he or she will take more trouble to carry out further processing of the cue. Similarly, whereas a casual glance at a person's face may not lead to recognition, if the person proceeds to greet you in a friendly fashion, further information is typically generated in an attempt to remember where you have met the person before. Such self-induced reconstructive processing is presumably utilized much more extensively in recall; in recognition, however, where retrieval information is usually richer, the processing follows more directly from the retrieval cue itself. Thus, in overview, we are arguing that retrieval processing, like input encoding, is under strategic control; the type and amount of elaborative processing carried

Distinctiveness can be manipulated "episodically" by varying the similarity of other encodings in the same experimental situation; presumably, distinctiveness can be made less localized by inducing encodings that differ from all previous encodings.

A further factor of major importance in retrieval is the congruity of the target encoding with the structure of the system. The organized structure of the system constrains and guides processing of retrieval information; so that if an event was compatible or congruent with the system on first presentation, it is likely that the resulting encoding can be reconstructed relatively easily during retrieval, thereby allowing remembering to occur. There is a paradox inherent in this view, in that commonly occurring or expected events will be encoded easily by the system but will also leave traces that are highly similar to those of many past events; thus accurate reconstruction can occur at retrieval, but performance will be reduced by the cue-overload effect. Optimal retention apparently occurs first in situations where an unusual event is encoded and excellent retrieval information is provided, as in the recognition of rare words (Gregg, 1976; Schulman, 1967) or of low-ranking category exemplars (Jacoby & Craik, 1978; Schnur, 1977). Retention levels are also high when the event can be analyzed by a highly organized section of the cognitive system, which arguably permits fine-grained differentiation of encoded events and guides reconstructive retrieval (Gibson & Gibson, 1955; Saltz, 1971). In this second category could be placed the mnemonic feats of master chess players (De Groot, 1965) and the excellent remembering of events with high emotional or personal implications (e.g., Keenan, MacWhinney, & Mayhew, 1977; Rogers, Kuiper, & Kirker, 1977).

Finally, in this section we endorse the importance of the interactions between encoding and retrieval operations stressed by Tulving and his colleagues (e.g., Tulving & Thomson, 1973). Fisher and Craik (1977) have shown that words encoded semantically are best retrieved by semantic cues, whereas words encoded phonemically are best retrieved by phonemic cues—a result illustrating Tulving's encoding specificity principle. However, they also found that retention levels were substantially higher in the case of semantic encoding/semantic cue than with phonemic encoding/phonemic cue. Fisher and Craik thus argued that both input-output compatibility and the nature of the code were necessary to describe the results fully, although this conclusion has been questioned by Tulving (1978). In the case of word recall, it is possible to compare retention levels between different encoding-cue combinations, but in other tasks such comparisons may be meaningless. To give a rather bizarre example, if two groups of naive Martians were presented with bicycles and one group was set to learn to ride them while the second group's task was to study the bicycles' shape by making drawings, it is reasonable to suppose that subsequent testing would reveal that the "learn to ride" group could ride

better than members of the "learn to draw" group and vice versa. However, it is just not possible to compare the riding skill of the "learn to ride" group with the drawing skill of the "learn to draw" group. In terms of memory research, it follows that the criterial memory task must be appropriate for the specific learning operations carried out initially (Bransford, Franks, Morris, & Stein, 1978; Jacoby, 1973b). Whether or not it is meaningful to compare different encoding-retrieval combinations may depend on the level of description adopted by different theorists.

Two further important distinctions have recently been drawn in memory research; the distinction between episodic and semantic memory (Tulving, 1972) and that between memory viewed as a system of traces and memory viewed as global "stage-setting" changes in the system (Bransford, McCarrell, Franks, & Nitsch, 1977). We comment on these distinctions briefly from the viewpoint adopted in this chapter.

EPISODIC AND SEMANTIC MEMORY

Tulving (1972) introduced these terms to distinguish memory for specific autobiographical events tied to a particular time and place (episodic memory) from a person's general knowledge of the world (semantic memory). We find this distinction a useful one but again argue that a conceptual continuity may be more useful than the implied dichotomy of episodic and semantic memories. For example, although it is clear that meeting a new person briefly in a certain setting constitutes an episode, how do we classify our memory of the person's face viewed from several different angles or the gradual build-up of knowledge about the person as we meet her or him in different surroundings? It seems clear that "pure" episodic memories shade off into generalized semantic memories through learning and into memories that are specific, for example, to one object viewed in different surroundings.

One way of characterizing the episodic–semantic continuum is as a hierarchy, with episodes in specific contexts forming the bottom nodes and information comon to several episodes represented by nodes at the next level up. Thus higher levels of the hierarchy would represent increasingly generalized information about relatively wide classes of specific events. In fact, the information represented by higher nodes could be termed *learning*, whereas the lowest nodes would be typically termed *memories*. It is immediately clear that such a hierarchical representation is unsatisfactory if it exists on one plane only; information common to Nodes *a*, *b*, *c*, and *d* may be represented by a higher Node, *x*; but there may well be some other dimension of similarity between Nodes *a*, *c*, *g*, and *h* represented by Node α lying on a different plane.

It seems generally agreed by present-day cognitive theorists that the generalized knowledge abstracted from many episodic experiences subsequently functions as an interpretive system to analyze and comprehend further events. By this view, higher levels of the hierarchy proposed earlier would be utilized relatively often, whereas terminal nodes would be accessed and activated only when a specific episodic memory was retrieved. Speculatively, higher level general procedures may be relatively easy to access and utilize, whereas episodic representations may require more effort and precise guidance from input stimulation before they can be activated. It is an interesting question whether the ability to reactivate episodic memories arose later in developmental and evolutionary history than the ability to utilize general procedures. It seems likely that one major evolutionary advantage enjoyed by man is the ability to reactivate episodic memories and thus be able to *reflect* on specific past events as opposed to merely being able to *utilize* past experience in a relatively general way.

MEMORY AS "STAGE SETTING" AS OPPOSED TO A TRACE SYSTEM

Bransford et al. (1977) have argued that memory should not be viewed as a system of records but rather that the whole system is in some degree modified by successive events, so that when an event recurs it is dealt with differently on its second occurrence than it was on its first. By this view, "learning" consists of modifications to the cognitive system that allow the system to differentiate between stimuli in a finer grained fashion (cf. Gibson & Gibson, 1955; Saltz, 1971), and "memory" reflects the system dealing with events in a skillful fashion. Thus memory is to be understood as the system "setting the stage," or acting as a background for the interpretation of novel and familiar events. Similar views have been put forward by Kolers (1973) and Restle (1974). As discussed earlier in the *Encoding and Retrieval* section of the present chapter, we agree that such a view can provide a basis for feelings of familiarity but do not see that it allows a description of memory for specific episodes.

The main point of the present section, however, is to argue that a controversy between memory as stage setting and memory as a system of records is unnecessary. One way of integrating the two approaches is to postulate that the cognitive system can work in a variety of modes ranging from "comprehension"—in which past learning serves as the background and attention focuses on the incoming events—to "remembering"—in which case new inputs (retrieval cues) act as the background and the attentional focus is on reactivation of some encoded aspect of past experience. In the latter case, the reactivation can be of relatively general information—as in question-answering—or of context-specific information—remembering a particular event.

CONCLUSIONS

In this chapter we have attempted to paint a rather broad picture of the factors important for an understanding of human memory processes. We believe that such a global approach may be useful at present; once many theorists agree on the general outlines of a satisfactory theory, the notions can be refined by a variety of means including experimentation, mathematical formalization, simulation, and further conceptual analysis.

Although the present ideas have arisen indirectly from the work on levels of processing (Craik & Lockhart, 1972; Craik & Tulving, 1975), it is obvious that many features of these earlier models have been de-emphasized or dropped. The notion of a linear sequence of processing stages has gone, for example. Elaboration or extensiveness of processing is more emphasized, but we still stress that some types of encoding are more beneficial for memory than are others: namely, encodings (either "sensory," pictorial, or linguistic) that are rich in associative potential and are encoded in highly structured parts of the cognitive system. Also we have attempted to integrate notions of input processing to the ideas of encoding, retrieval interactions developed by Tulving and his associates.

Our central argument is that an elaborated stimulus leads to a distinctive encoding; distinctiveness is not absolute, however, but is relative to a background of other encoded events on one or more encoding dimensions. The event will be well retrieved to the extent that the retrieval cue can be elaborated in turn to reconstruct the specific target encoding and not other, similar encodings.

Is learning then a matter of differentiation and distinctiveness as argued by Gibson and Gibson (1955), Saltz (1971), and others? To some extent, we are endorsing this notion, although we also wish to incorporate some ideas of the type of encoding and to stress the notion of memory as the record of perceptual analyses and ideas of compatibility between encoding and retrieval processes. A further way in which we differ from the Gibsons' position is that we do not see differentiation as being in competition with reconstructive elaboration; in our view, they are two sides of the same coin. Where the Gibsons (1955), and other theorists who have adopted their viewpoint, talk of the organism becoming attuned to the richness of the stimulus array or educated to pick up information from the light, we are asking what is the nature of that attunement or education; how might we describe the changes in the processes inside the head? Presumably, *something*

must correlate with changes in attunement and education. Our description is in terms of elaborative processes and their relations to retrieval conditions.

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9 The Primacy of Perceiving: An Ecological Reformulation of Perception for Understanding Memory

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INTRODUCTION

In what way do perception and memory relate? Self-evidently, an answer to this question depends a good deal on how the two terms in the sought-after relation are construed. It is equally self-evident that the two terms, *perception* and *memory*, are so intimately bound that given a definition of one, the interpretation of the other is necessarily constrained.

We present an overview of kernel themes that collectively provide the contemporary orientation to perception. These themes have at their source, or so we claim, an overarching dualism that conceives of the animal and its environment as logically independent. This collection of themes is the perceptual theorist's legacy of (at least) the last 500 years; and given the interdependence of the conceptions of perception and memory, it follows that the understanding of perception induced by this legacy conditions our understanding of memory in the large, and not just its relation to perception. It is our major intent to contrast the traditional themes with themes of a radically different kind that have as their base animal–environment synergy (or reciprocity). Collectively, these themes identify what might be called an ecological orientation to perception. Viewed ecologically, perception takes an unconventional form: It appears to be a property of the ecosystem rather than of the animal as such; its laws seem to require a three-term logic for their expression; and it does not appear to be propositional and mediated—to the contrary, perception is nonpropositional and direct. The ecological reformulation of perception offers a new framework in which to pursue the puzzle of memory.