Johnson, M.K. (1983). A multiple-entry, modular memory system. In G.H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 17, pp. 81-123). New York: Academic Press.

A MULTIPLE-ENTRY, MODULAR MEMORY SYSTEM

Marcia K. Johnson

STATE UNIVERSITY OF NEW YORK AT STONY BROOK
STONY BROOK, NEW YORK

I. Introduction

Memory is what allows our past to modify how we deal with events in the present. The most impressive thing about memory is the range of functions that it supports. The same memory system that recalls your vacation learns to play racketball. The same system that memorizes a part in a play is startled by faces that resemble the mugger who got your wallet. The same system that can instantly classify a strange animal as a bird struggles to identify the pharmacist when you run into him in the grocery store.

Once it was thought that a few universal laws would apply to all of these situations:

> A continuous series of cases extends from the revival of one's own experiences at one extreme to the automatic performance of a learned movement at the other, and the whole series belongs together. The difference between the extremes is a matter deserving of attention, but the likeness is more fundamental. (Woodworth, 1938, p. 5)

G. H. Bower (Ed.)
THE PSYCHOLOGY OF LEARNING
AND MOTIVATION, VOL. 17

ISBN 0-12-543317-4

The search for general laws of learning was sometimes expressed as an attempt to explain all learning in terms of a single paradigm, for example, in terms of trial and error learning or in terms of classical conditioning (see McGeoch, 1952). This strategy was not successful, and movement toward specialization intensified (e.g., classical conditioning, operant learning, verbal learning, semantic memory).

This specialization is good for many purposes, but there is a cost. A memory system designed for one function (e.g., language comprehension) would not necessarily be the same as one designed for multiple functions (e.g., language comprehension, pattern recognition, concept learning, dancing, developing preferences). Thus, it should not surprise us that theories created to account for a relatively limited range of facts ultimately prove to be limited. On the other hand, acknowledging the range of activities memory must perform does not necessarily commit us to looking for a single mechanism for all of them (Tolman, 1949).

In this article I describe a general approach to memory in the form of a model of memory called a multiple-entry, modular memory system (MEM). The present model proposes that the multiple functions that memory serves are accomplished by several interacting, but distinguishable subsystems. To a large extent, these subsystems respond to different aspects of experience; hence, any particular event is likely to create multiple entries, that is, entries in more than one subsystem. This model tries to resolve or clarify a number of issues, for example, the controversy between trace theories and constructive theories of memory, the role of attention in establishing long-term memories, and the relations among various measures of memory (e.g., recall and recognition). In addition, MEM provides a framework for generating new hypotheses about a number of other areas, for example, the relation between memory and emotion, the relation between specific, autobiographical memories and general knowledge, and the problem of characterizing memory disorders.

II. The Model

A. Overview

Any model of memory should address a fundamental question: What is the relation between what we remember and what "really" happened? Memory theorists essentially ignored this question for years by explicitly or tacitly adopting a sort of naive realism. According to naive realism, our memory stores copies or traces of "stimuli," and the "strength" of a memory is directly related to such things as how frequently and how recently we have perceived the corresponding stimulus. This view is the one that dominated work on memory from the time Ebbinghaus (1885/1964) first initiated experimental work on memory in the late 1800s until quite recently.

While there have always been critics who questioned this view (e.g., Bartlett, 1932), it was not until the late 1960s and early 1970s that naive realism was finally overtaken by what now might be called "naive constructivism." Although not identical to information processing, constructivism was fueled by the information-processing approach to cognition. In the view of many psychologists, the central feature of memory is rapid decay of information in the physical stimulus unless it is recoded. Recoding is viewed as a series of processes in which earlier products are discarded as successively higher recoding operations take place. For example, visual features detected by feature detectors become letters, letters become words, and words become meanings. The idea of recoding can be extended so that the highest levels of code are "holistic ideas" or "propositions" arranged according to familiar "schemata." From this viewpoint, the representation of a complex event is a highly abstract, "constructed" representation and one that is not necessarily veridical or true to reality. In the constructivist view, we do not remember what we saw, but what we thought.

Neither of these approaches can account for all of the data. People do embellish information and then sometimes mistake their embellishment for fact (e.g., Johnson, Bransford, & Solomon, 1973); at the same time, very specific sensory detail appears to be preserved in memory (e.g., Hintzman & Summers, 1973). Naive realists did not generate theories that could easily account for the sometimes dramatic errors and distortions in memory. Naive constructivists have not generated theories that can easily accommodate the sensitivity and sometimes remarkable accuracy of the memory system. In MEM, both accurate and inaccurate memory are consequences of a system that evolved for multiple functions.

A basic idea represented in the MEM model is that multiple functions are very likely accomplished by a memory composed of independent, interacting subsystems. In MEM, there are three major subsystems, the sensory system, the perceptual system, and the reflection system. The first two abstract, store, and revive external, perceptually derived experiences, and the third creates, stores, and revives internally generated events (Johnson & Raye, 1981).[1]

[1]I should acknowledge at the outset that the boundaries between the sensory, perceptual, and reflection subsystems are not clear. However, I think these subsystems comprise useful "fuzzy sets" for organizing findings, hypotheses, and speculations.

Each of the subsystems is specialized for a number of functions, for example, the sensory system for detection of stimuli and the development of certain sensory–motor skills, the perceptual system for identifying relationships among objects and recognizing the familiar, the reflection system for planning and for voluntary recall of events. A particular event may be processed by all subsystems, creating memory traces, or "entries" in all subsystems (see Fig. 1). If you stare at Fig. 1, it reverses in Necker-cube fashion: each of the subsystems overlaps with the other and each can be seen as in front, in back, or in the middle. As this characteristic of the figure suggests, the various systems interact continuously. The subsystems should be imagined as working more or less simultaneously rather than serially; they are more like light filters responding to different aspects of experience than stages in a transformation.

To illustrate the idea of multiple entries, consider the activity of learning to play tennis. This is a complex skill in which various components are probably largely mediated by different subsystems: learning to anticipate the trajectories of tennis balls is a sensory function; learning to see relations among the opponent's position on the court, posture, and racket orientation that signal his or her probable shot (lob, down the line, etc.) is a perceptual function; learning to recognize the opponent's strategy or to plan one (vary pace, baseline game, etc.) is a reflection function.

Consider the activity of reading a story. Sensory processes create sensory entries that reflect the configuration of light and dark on the page, and the

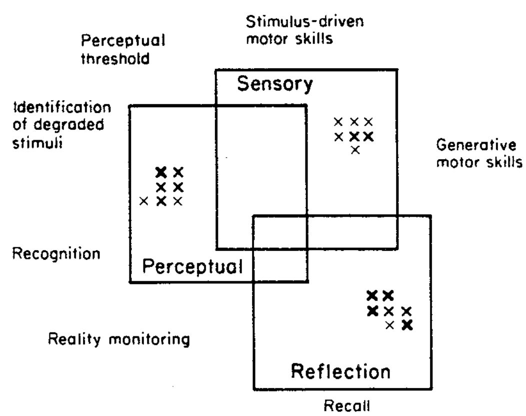

Fig. 1. A particular event creates entries in three subsystems of memory, sensory, perceptual, and reflection. The shading indicates activated entries; the darker the shading the greater the likelihood that the activation will recruit attention. Various memory tasks are listed near the subsystem(s) that they are most likely to draw upon.

visual scanning operations induced by this configuration as various parts of the stimulus are localized and figure–ground relations emerge. Perceptual processes create perceptual entries that reflect specific instances of identifiable patterns, for example, words and phrases in a particular typeface, in a particular spatial arrangement on the page. In addition, reflective entries preserve a record of internally generated thought processes such as imaging, drawing inferences, and other embellishing. Later, subjects might show reduced perceptual thresholds for words in the stories, be able to discriminate exact words from paraphrases in a forced-choice recognition test, and yet produce pragmatic inferences in recall (i.e., claim that they read information that they only inferred). These results are not contradictory; they are all possible because memory is a multiple-entry system.

We have evolved memory structures that tie us to reality in fairly direct ways through our sensory and perceptual systems. These systems allow us to detect highly probable recurrences and invariants (Brunswik, 1956; Gibson, 1966) in an external reality to which we must adapt. However, we also have evolved mental structures that allow us to produce and retain a "self-generated" reality as well. These allow us the independence from ongoing perceptual stimulation that is necessary for anticipating, drawing inferences, reminiscing, planning, and otherwise manipulating ideas. The benefits of the reflection system for creative invention are clear, but we pay for them. The cost is occasional confusion between the real and the imagined in memory (Johnson & Raye, 1981).

In general, failure on a memory task does not necessarily imply a loss of information from memory. Different memory tasks draw differentially on different subsystems in MEM; hence, an entry not revealed by one memory task may be revealed by another. This means that while subsystems interact continually, different subsystems may predominate at different times.

The memory subsystems also interact with attention mechanisms. At any given moment, only part of memory (potentially consisting of entries and functions from all subsystems) is activated—this is "activated memory." Only a subset of activated memory receives attention, that is, reaches awareness. Information within and between the different subsystems differs in ability to recruit attention; thus, some entries inhibit others from gaining attention.

These ideas are represented graphically in Fig. 1. They are developed in more detail in the body of the article, along with a consideration of the way in which MEM relates to certain other issues, for example, emotion and memory, semantic versus episodic memory, and amnesia. I shall begin with a brief characterization of each subsystem and then consider evidence bearing on differentiating among them.

B. The Reflection System

The term "reflection" is taken from the British philosopher, John Locke, who suggested that our knowledge originates from two sources, experience and reflection. In MEM, reflection is the active thinking, comparing, and judging function of the mind. It includes planning, creating images, organizing, elaborating, rehearsing—the processes emphasized by cognitive theorists. What these processes all have in common is that they are generated by the subject. Compared to sensory and perceptual processes, they depend less on immediate perceptual data. The reflection record preserves our interpretation of and "commentary" on perceptual events, our fantasies, efforts to understand, and our attempts to control what happens to us.

Many activities that we must perform without the support of external stimuli depend heavily on the reflection record. For example, the reflection system allows us not only to generate hypotheses, but to keep track of the ones we have already tested and evaluate new ones in light of prior evidence and goals (e.g., Levine, 1966; Newell & Simon, 1972). It allows us to construct mental maps and other representations of related facts and use them to guide actions or responses in memory tests (e.g., Bransford, Barclay, & Franks, 1972; Levine, Jankovic, & Palij, 1982). The reflection system helps us to find relationships between new information and old knowledge so that we can comprehend and draw inferences (e.g., Bransford & Johnson, 1973; Kintsch, 1974).

Free recall of events especially depends on entries in the reflection system. Reflection processes integrate and organize (e.g., Mandler, 1967; Tulving, 1968) by creating or reactivating relationships between one event and another (e.g., between target items and other information, such as other targets, elements of the experimental context, or episodic events from the subject's life). The associations produced by reflection activities have been given various names, for example, interitem (Mandler, 1980), contextual (Jacoby & Dallas, 1981), elaborative (Craik & Tulving, 1975), and vertical (Wickelgren, 1979). There is considerable evidence that high levels of free recall depend on such reflective activities (e.g., Bellezza, Cheesman, & Reddy, 1977; Tversky, 1973).

Not all reflective activities are organizational. Some are less likely to create interrelations among events. Covert rehearsal that is not elaborative ("maintenance rehearsal," Craik & Watkins, 1973) does little to improve recall, but increases recognition (Glenberg, Smith, & Green, 1977; Rundus, 1977). Thus, recognition can draw on the reflection record, although, as emphasized in the next section, the perceptual record appears to be particularly influential in recognition under many circumstances (cf. Mandler, 1980).

Both elaborative and nonelaborative reflection typically require "effort," use "cognitive capacity," occupy "attention," or depend on "controlled processes" (Hasher & Zacks, 1979; Kahneman, 1973; Shiffrin & Schneider, 1977; Tyler, Hertel, McCallum, & Ellis, 1979). However, reflection should not be equated with cognitive capacity or attention; many perceptual processes use capacity or recruit attention as well.

C. The Perceptual System

The information comprising particular events varies in degree of "organization" much as a random dot pattern (e.g., Julesz, 1971) differs from a meaningful scene (Biederman, Rabinowitz, Glass, & Stacy, 1974; Friedman, 1979; Mandler & Stein, 1974) or a fly buzzing erratically around the room differs from a ping pong game. The distinction between sensory and perceptual systems in MEM attempts in part to capture this sort of difference. As the discussion below of the sensory system suggests, random dot patterns may create permanent memories (Stromeyer & Psotka, 1970), and you could get better at tracking the fly; however, phenomenal experience, including the sort of remembering that is associated with a sense of pastness, is ordinarily dominated by the more organized products of the perceptual system. That is, perceptual functions give our experiences the characteristically organized and relational quality that they have, qualities emphasized by the rationalist philosophers (e.g., Descartes and Kant) and Gestalt psychologists (cf. Goldmeier, 1982).

Perceptual functions involve both innate and learned ways of organizing stimuli. For example, certain innate, automatic coding categories or processes may register experiences as "causal," or "similar," or "symmetrical," or, in the case of humans, as "face-like," or "language-like." Other temporal and spatial aspects of experience might be given by innate qualities of perceptual functions as well. The fact that elements are near each other or have common fate would automatically make them cohere into organized percepts. Learned perceptual categories build up with experience as well. Hence, at some time we begin to perceive whole words, rather than individual letters, etc.

The perceptual record is particularly important in accounting for the storage of complex patterns and in producing a sense of familiarity, that is, the sense of having seen something before. Perceptual entries create and are in turn guided by schemas or mental structures (Hochberg, 1981). However, these are *perceptual* schemata and should not be too casually equated with other sorts of mental contexts (Bransford & Johnson, 1973), schemata (Bartlett, 1932) and scripts (Schank & Abelson, 1977) that have been shown to influence memory, and are much more likely to involve reflective processes. The point is important because current textbooks tend to stress findings suggesting that memory is based only on meaning and not on perceptual characteristics of stimuli, but this is not the case. People are better at recognizing that they have seen words before if the typeface in which the words are displayed on the test is exactly the same as the typeface in which the words were shown originally (Hintzman & Summers, 1973). The same is true for auditory features—subjects are better able to recognize a word they heard before if it is spoken in the same voice on the test (Craik & Kirsner, 1974; Geiselman & Bjork, 1980). For prose material, originally presented sentences can be discriminated from paraphrases over intervals at least as long as a week (Bates, Masling, & Kintsch, 1978; Dorfman, 1979; Keenan, MacWhinney, & Mayhew, 1977; Kintsch & Bates, 1977). Memory for exact wording and specific details has been reported many times (e.g., Hasher & Griffin, 1978; Tyler & Ellis, 1978; Tzeng, 1975), even for situations very like those originally interpreted as refutations of verbatim memory (e.g., Bransford & Franks, 1971; Sachs, 1967). This sensitivity of memory to repetition of surface features and specific detail challenges the view that all we store are abstract "meanings." Specific perceptual aspects of events are stored as well.

D. The Sensory System

It has often been proposed that sensory information that is not encoded beyond the sensory level is rapidly lost (e.g., Atkinson & Shiffrin, 1968; Broadbent, 1958; Craik & Lockhart, 1972; Neisser, 1967; Sperling, 1960). An experiment by Turvey (1967) using the Sperling task illustrates this view: on each trial, subjects received a 50-msec exposure of a 3 × 5 matrix of randomly selected digits. The subjects were cued with a tone to recall one of the three rows of digits. One matrix was repeatedly interspersed among the others, but recall was not significantly better on tests involving the repeated matrix than on tests involving nonrepeated matrices. Turvey (1967) suggested that the Sperling task produces *preperceptual* traces that "should be excluded from the domain of memory (p. 292)."

In contrast, MEM assumes that elementary sensory information is stored in a permanent form. However, "stored" does not necessarily imply that an entry is accessible to voluntary recall processes. Changes in memory as a function of experience may reveal themselves in some tests, but not others, for example, in reduced perceptual threshold or faster processing (e.g., in lexical decision or naming tasks) but not recognition, or in recognition but not recall (Johnson, 1977). According to MEM, performance on recall tests is particularly dependent on prior reflection. The Sperling procedure, involving brief presentations and massive interference from recombinations of the same items, obviously is designed to prevent reflection activities. Yet, with enough repetitions, even in this task recall does improve (Merluzzi & Johnson, 1974). Tests other than recall, however, should be more sensitive to effects of prior sensory processing. This prediction receives support from an experiment by Kunst-Wilson and Zajonc (1980). They found that subjects liked previously presented random polygons better than new ones, even though the prior exposure duration of the "old" polygons was only 1 msec! This result contradicts the idea that brief exposures that presumably produce only sensory processing have only transient consequences, and supports the idea that a sensory record is created by such sensory processing.

There is other evidence that relatively "low-level" processing leaves an entry. For example, Haber and Hershenson (1965) showed that subjects' ability to identify a word increased over trials even though the duration of presentation on each trial was briefer than what would be necessary to identify the word on the first trial. People are faster in deciding a letter string is a word the second time it is presented, and the facilitation is greater when the word is presented in the same modality (e.g., visual–visual rather than auditory–visual) on both occurrences (Forbach, Stanners, & Hochhaus, 1974; Kirsner & Smith, 1974; Scarborough, Cortese, & Scarborough, 1977). Evidence continues to accumulate showing that relatively "shallow" levels of processing produce quite long-lasting consequences in memory (Jacoby & Dallas, 1981). Further demonstrations of memory for specific aspects of events await only the application or development of more sensitive memory tests (Johnson, 1977).

The sensory system in MEM is presumed to be sensitive to quite elementary properties or changes in the stimulus array. Just what these sensory properties are remains to be clarified. Some suggestions are made in the next section. However, it is clear that we shall not look for them unless we propose that they are there. In addition, those properties that create memory entries will probably have to be specified for each sensory system individually.

Whatever these properties, the fact that they accumulate in the sensory system allows us to get better with experience at dealing with stimulus information of which we are rarely, if ever, aware. Sensory properties allow us to know that an event has occurred without necessarily knowing what the event was. Furthermore, the sensory system is probably involved in establishing associations or schemata relating stimulus properties and some responses, for example, between the sounds that we make and articulatory movements that produce them. In general, the sensory record probably plays a large role in improvements in various motor skills, such as developing hand–eye coordination, learning to make appropriate postural adjustments to changes in external cues, adjusting to weightlessness, improvements in tracking tasks, and other largely stimulus-driven tasks (e.g., Kowler & Martins, 1982). In short, information that is not accessible to voluntary recall and not necessarily recognizable as comprising familiar patterns can be extremely useful information in that it can support the performance of rather complex skills. The sensory record preserves and accumulates such information.

E. Differentiating among Subsystems

The difficult problem is to analyze the memory system into component processes. How many different processes do we need? Surely we need more than one undifferentiated process, but not a separate process for every unique event. We need a way of classifying or grouping some processes together because they have something in common. One classification scheme is suggested by MEM; processes are grouped into the major categories of sensory, perceptual and reflective; within each of these are subprocesses, for example, seeing, hearing, planning, and comparing, and each of these could be further subdivided.

Unfortunately, we cannot simply classify these systems in terms of tasks because performance in almost any task will be supported by more than one subsystem. For example, there are sensory and perceptual components in tasks that we think of as largely reflective (e.g., reading and speaking), and there are reflective components in tasks we think of as largely sensory and perceptual (e.g., playing tennis and driving). To fully characterize learning and memory in such complex situations would require an understanding of the way that separate subsystems work, the way that they interact, and the way that their interaction changes with practice. For example, reflection may help define perceptual patterns to look for, but after extended practice, perception in terms of these patterns may proceed without reflection.[2] However, although the job of disentangling sensory, perceptual, and reflection subsystems is difficult, there is some reason to believe that thinking in terms of these subsystems might result in a useful conceptual framework.

1. *Evidence from Studies of Cognition*

Several lines of evidence suggest that it is reasonable to categorize memory functions and records in terms of the subsystems proposed in MEM.

[2]An arrangement in which different subsystems had substantial amounts of independence would be especially valuable for doing more than one thing at a time (e.g., chewing gum, driving a car, and rehearsing the day's lecture).

First, while reflectively generated (e.g., imagined) and externally derived (perceived) events are clearly similar, they are not exactly the same. If you take fairly clear cases of perceived and imagined events, such as a visually presented picture and an imagined picture, the features do not seem to be equally distributed across perceived and imagined memories. For example, memories of perceptions typically have more specific sensory features than memories of imaginations, and imagination creates a more embellished record of the operations involved in generating the image. These differences can be used by subjects to discriminate between perceived and self-generated events in memory ("reality monitoring," Johnson & Raye, 1981). If you make imagined events more like perceptual events by increasing their sensory–perceptual characteristics (e.g., Johnson, Raye, Wang, & Taylor, 1979; Foley & Johnson, 1982) or by decreasing the reflective operations that went into producing them (Johnson, Kahan, & Raye, 1981; Johnson, Raye, Foley, & Foley, 1981), you will decrease the accuracy of reality monitoring. Thus, as shown in Fig. 1, reality monitoring draws on both perceptual and reflection records.

The present model, along with the reality-monitoring model, provides a resolution of the controversy between realists and constructivists: both perceptual and reflective entries are preserved. A test drawing on the perceptual system is likely to yield evidence for physical features; a test drawing on the reflection system is likely to yield the sorts of omissions, elaborations, and distortions introduced during reflection. Failures in reality monitoring will sometimes lead people to treat reflective entries as if they had been perceptions, and vice versa (for a description of decision processes involved in reality monitoring, see Johnson & Raye, 1981; for a review of evidence related to the realist/constructivist controversy, see Alba & Hasher, 1983). As a task, reality monitoring can potentially help to illuminate the similarities and differences in entries derived from perception or generated via reflection because it explicitly requires discrimination between the two.

Second, the subsystems can at least partially be dissociated on the basis of the patterns of relationships among various memory tasks. If we were dealing with a unitary memory system in which information existed only at various levels of strength, some memory tests would appear easier than others because they would have lower thresholds for successful performance. However, overall, particular variables should have the same effect on performance on all measures. Furthermore, any memory that exceeded the threshold for a more difficult test should exceed the threshold for an easier test. Both of these criteria for a unitary system can be shown to be false. For example, reality monitoring is not necessarily correlated with measures of recall or recognition (Johnson & Raye, 1981). Furthermore, recognition almost always increases with frequency of occurrence, and recall often does not. In fact, measures of cued recall and recognition for the same items indicate that success on one task is largely independent of success on the other, suggesting that different features are sampled by the two memory tasks (Flexser & Tulving, 1978). This independence is consistent with the suggestion made above that recall draws heavily on the reflection system while recognition draws heavily on the perceptual system. Not only are recognition and recall at least partially independent, but measures of recognition and measures related to perceptual threshold also appear to show some independence (Jacoby & Dallas, 1981). This would be expected if threshold tasks draw heavily from the sensory system and recognition tasks from the perceptual system.

Third, it is possible that selective attention tasks can be developed to help illuminate the difference between the sensory and perceptual systems. For example, Rock and Gutman (1981) showed subjects a series of overlapping green and red nonsense figures and asked the subjects to attend selectively either to the green figures or the red figures. On a later recognition test, subjects could not distinguish the unattended shapes from other, similar shapes. Rock and Gutman (1981) use these data to make the point that perception of shape requires attention: "Phenomenal shape entails an apprehension by the observer of the exact spatial interrelationships of the parts of the figure to one another and of the relationships of these parts to the up–down, left–right spatial coordinates (p. 282)." It would also be consistent with the present model if objects seemed familiar only if they had been a phenomenal object in the past in the sense described by Rock and Gutman (see also Hochberg, 1971); the sort of processing that produces a unique and organized whole would be characteristic of the MEM perceptual system. As has already been suggested, successful recognition that an object has occurred before very likely depends on perceptual entries. Equally important, however, is that in a subsequent experiment by Rock and Gutman specifically designed to discover what, other than shape, might have been processed, subjects did remember some things about an unattended figure—the size, whether its shape was open or closed, and whether the contour of the shape was a continuous line, a dotted line, a dashed line or composed of small ×s. Rock and Gutman (1981) proposed that there was "a failure of form perception simultaneous with successful perception of other properties of the object" (p. 283). It is possible that these other properties were picked up by what in MEM is called the sensory system.

Similarly, Treisman and Gelade (1980) have proposed that there are a number of elementary dimensions including orientation, brightness, direction of movement, and texture segregation or figure–ground grouping that are combined to produce conscious percepts. These elementary dimensions are the sorts of properties proposed here to be included in the MEM sensory system. The present framework proposes, in addition, that sensory entries accumulate over successive occurrences and that they can enter into functional associations with other stimuli and responses, including movement and emotions.

In summary, while there is still much to be done in the way of establishing criteria for deciding when we are dealing exclusively (or even primarily) with one subsystem in memory and not another, the present framework provides a vehicle for organizing some of the available evidence and for suggesting further lines of research. Without further work, only a tentative grouping of tasks that might help us explore characteristics of the various subsystems can be offered. Tasks that appear to reflect the influence of the sensory record include measures of the effects of prior exposure on perceptual threshold or identification of very briefly presented stimuli (Jacoby & Dallas, 1981), on identification of degraded stimuli (Warrington & Weiskrantz, 1970), lexical decision (Scarborough *et al.*, 1977), naming (Durso & Johnson, 1979), and the development of preferences (Kunst-Wilson & Zajonc, 1980). Selective attention tasks (e.g., Rock & Gutman, 1981; Treisman & Schmidt, 1982) are promising as well.

Properties of the perceptual record are likely to influence performance in recognition tests involving complex stimuli, for example, sentences (Keenan *et al.*, 1977), pictures (Biederman *et al.*, 1974; Tulving, 1981), faces (Light, Kayra-Stuart, & Hollander, 1979), and nonsense forms (Rock & Gutman, 1981). The characteristics of the perceptual record in memory might also be clarified by studying "implicit learning" (Reber & Lewis, 1977) and the development of perceptual categories (e.g., Cerella, 1979; Herrnstein & deVilliers, 1981; Posner & Keel, 1968) and their role in the memory of experts (e.g., Chase & Simon, 1973). Memory for perceptual information also can be assessed fairly directly, for example, by testing what subjects remember about the color (Nilsson & Nelson, 1981) or location of items (Johnson, Raye, Foley, & Kim, 1982; Rothkopf, 1971).

One of the major messages of cognitive research has been the importance of what are here called reflective activities in remembering, and the free recall task has been particularly revealing in this regard (e.g., Bartlett, 1932; Bower, 1972; Mandler, 1967; Tulving, 1968). The properties of reflective entries have been explored in the context of studies of cognitive maps (e.g., Hanley & Levine, 1983) and other representations constructed from sequentially presented information (e.g., Bransford *et al.*, 1972), and in studies of integration (e.g., Loftus, 1975), imagery (e.g., Paivio, 1971), and of the role of inferential processes, schemata and scripts (e.g., Bower, Black, & Turner, 1979; Bransford & Johnson, 1973). There have been relatively few attempts to explicitly compare the properties of memory entries created by reflection and those created by perceptual processes (e.g., Jacoby, 1978; Johnson & Raye, 1981; Peterson, 1975; Slamecka & Graf, 1978), but this provides a potentially powerful way of exploring characteristics of reflective entries.

2. *Neuropsychological Evidence*

The general scheme proposed in MEM also finds some support from research in neuropsychology. Some cortical zones are composed of neurons that are responsive to a specific sensory modality. Lesions in these areas produce fundamental sensory losses, such as the absence of sensation in an area of the visual field (scotomas). Other zones are also modality specific, but synthesize sensory input into more complex relations. Lesions in these areas produce agnosias, "the inability to combine individual impressions into complete patterns" (Kolb & Whishaw, 1980, p. 194). For example, Luria (1973) showed a patient a picture of a watch with several lines superimposed over it. The patient said it was a "chick hatching from an egg and some funny circles." It is as if the patient was basing an interpretation on some physical features of the stimulus, but suffered a severe disruption of the ability to resolve relational aspects of the picture. In still other zones "sensory modalities overlap, enabling the sensory systems to integrate their input and to work in concert with one another and with information already stored in the nervous system" (Kolb & Whishaw, 1980, p. 244). Lesions in these zones disrupt cross-modality matching, for example, identifying the unfamiliar object in a visual array that is the same as an object you feel with your hand but that you are not allowed to see. These lesions do not, on the other hand, disrupt basic vision, hearing, or somatic sensation.

There are other lines of neuropsychological evidence suggesting that different aspects of perception are mediated by different anatomical systems: in vision, the detection of intensity and location seem to be a function of one system, whereas pattern discrimination seems to be a function of another. For example, experiments with monkeys, rats, and hamsters indicate that lesions of the visual cortex disrupt pattern discrimination but not discrimination among lights differing in location. On the other hand, lesions of the superior colliculus disrupt localization, but not pattern discrimination (Schneider, 1969). The "fibers leaving the colliculus appear to connect with the motor control system for eye movements, head orientation, and postural adjustments" (Lindsay & Norman, 1977, p. 77). Patients have been reported who could grasp moving objects and report the direction of motion while at the same time claiming that they did not "see" the object (Weiskrantz, Warrington, & Sanders, 1974).

The point here is not to suggest that the sensory system and perceptual system can be equated with the specific brain structures mentioned above, but rather to point out that some aspects of perception function in the absence of others. This indicates that perception, even within a single modality such as vision, is composed of component processes with some degree of modularity. Thus, the conceptual division of perceptual memory into the subsystems used in MEM is at least physiologically plausible. Furthermore, both the physiological data and results of cognitive studies provide some reason to group together the detection of changes in brightness and elementary figure–ground relationships, localization of stimuli, and some basic motor functions in one system (sensory), and the detection of relational attributes, complex pattern perception, object identification, and familiarity in another system (perceptual). In a later section, evidence about amnesia patients will be discussed that is consistent with the idea that a third system (reflection) is largely responsible for establishing the conditions of voluntary recall and relating events to personal identity.

F. Activated Memory and Attention

Cognitive activities such as perceiving, thinking, or remembering create patterns of neural activation in the brain. This ongoing activation is sometimes called short-term memory, working memory, or activated memory. In MEM, activated memory consists of currently activated information from all subsystems, sensory, perceptual, and reflection. Activated memory is created by ongoing entry processes. But we are not equally aware of all activated entries; only a subset receive conscious attention (e.g., Posner, 1978).

1. Attention and Acquisition

Some investigators have proposed that only what is attended to or subjected to controlled processing is stored permanently in long-term memory (LTM) (e.g., Broadbent, 1971; Shiffrin & Schneider, 1977). In contrast, MEM proposes that whatever is processed by a subsystem is entered into the corresponding record.

Several different types of findings have been taken as evidence for the idea that storage depends on attention; however, an argument can be made that this evidence has either been contradicted by other findings or does not constitute the most stringent test of the attention-dependent storage hypothesis.

In studies of memory for prose, people typically remember general ideas better than exact wording (Bransford & Franks, 1971; Sachs, 1967). Because it is reasonable to assume that people pay attention to meaning and not to physical characteristics of the words that convey the meaning, such findings have been used to support attention-dependent storage (Shiffrin & Schneider, 1977). However, as mentioned previously, more recent evidence (e.g., Hasher & Griffin, 1977; Keenan *et al.*, 1977; Kintsch & Bates, 1977; Tyler & Ellis, 1978; Tzeng, 1975) shows considerable retention of specific detail, including exact wording, in memory for prose.

The results of studies in which orienting tasks are used to specifically direct attention to one attribute or another (e.g., sensory versus semantic or color versus form) of events suggest a similar conclusion. While what is attended to is usually remembered best, attention directed at a particular stimulus feature does not eliminate encodings based on other features. For example, Nelson and Walling (reported in Nelson, 1979) demonstrated that biasing a sensory encoding of a target word by presenting it with a rhyming context word (TOWER-*FLOWER*) did not eliminate the effectiveness later of semantic cues (ROSE) on a recall test.

Some of the most compelling evidence for the attention-dependent storage position comes from studies using the dichotic listening technique. When subjects shadow information presented to one ear, their memory for information presented to the other ear may not be above chance, even for items repeated several times in the unattended ear (Moray, 1959). One explanation is that such stimuli contact a representation in LTM, but are filtered out by preattentive processes and hence do not leave a trace of their occurrence. In the multiple-entry model, these are stimuli that become part of activated memory, but that do not recruit attention; they are "nonattended" stimuli, but they are entered in memory.

According to MEM, both subthreshold perception (in the sense of activated but not attended to) and subthreshold reactivation (memory revival) should have consequences for thought and behavior (see also Erdelyi, 1974). Furthermore, these consequences are viewed as permanent, not transient; for example, they should cumulate over successive subthreshold occurrences (e.g., Haber & Hershenson, 1965). Admittedly, there is not much evidence for this proposition. However, investigators have used relatively insensitive tests (recall and recognition) to look for memory for unattended information. Unattended information is not reflected upon and therefore would not be expected to be recalled. To the extent that reflective processes play some role in recognition, or to the extent that recognition depends on prior phenomenal perception, recognition would be poor as well. However, automatic activation of pathways (Posner, 1978), or sensory and perceptual processes that are stimulus driven (Norman & Bobrow, 1975), whether or not the subject attends, should create entries in memory. Thus, tests that are more likely than recall or recognition tests to draw on these entries, such as measures of perceptual threshold or processing time in lexical decision or naming tasks, should detect prior exposure to unattended information.[3]

Along these lines, evidence is accumulating that information that is not perceived in the sense of consciously identified can affect subsequent processing. For example, subjects in a lexical decision task are asked to press one button if a word occurs and another if a nonword letter string occurs. Responses to a word such as *doctor* are faster if a related word precedes it, for example, *nurse* (Mayer & Schvaneveldt, 1976). Facilitation from related words occurs to about the same degree even if the first, prime word is masked so that it cannot be identified (Fowler, Wolford, Slade, & Tassinary, 1981). Similarly, naming a picture is faster if it is preceded by a related picture, even if the prime picture was presented at an exposure duration brief enough to preclude identification of the prime (McCauley, Parmelee, Sperber, & Carr, 1980). These effects are consistent with MEM. Furthermore, MEM would expect that these effects are not necessarily restricted to a few milliseconds but should persist over substantial intervals and build up with repetitions. Consistent with this prediction, Wilson (1979) reported that subjects had a greater preference for melodies previously repeated on the unattended ear during a dichotic listening task, compared to new melodies.

In addition, Kellogg (1980) makes the important point that the nature of the new items on a test will influence whether subjects show memory for unattended information. New items that are very similar to targets will yield low scores (this is true even for attended information); new items that are less similar may reveal that some characteristics of the unattended information were stored. Kellogg did find significant memory for the class of faces that had been presented as unattended distracting stimuli during a mental arithmetic task. A similar conclusion can be drawn from the previously mentioned study by Rock and Gutman (1981); an appropriate selection of new items (e.g., differing from the target in size) revealed that subjects stored certain characteristics of unattended visual figures. In short, it seems likely that if investigators looked for evidence of memory for nonattended stimuli with more sensitive tests, they would find it.

Finally, as another argument against attention-dependent storage, consider complex tasks such as playing a piece on the piano, typing, reciting a

[3] Eich (1982) has recently reported evidence consistent with the present prediction. Subjects shadowed a passage presented in one ear while two-word phrases (e.g., taxi fare) were presented in the other ear. Later, subjects were not able to recognize words presented in the unattended ear. However, the results of a spelling test indicated that the unattended information had been stored; compared to unpresented control words, subjects were more likely to spell homophones (e.g., fair/fare) in the way consistent with the interpretation that had been biased by context during presentation in the unattended ear (e.g., taxi fare).

poem, baking bread, or reading. With extended practice, such activities become relatively "automatic" in that they can be done while other "secondary" tasks are performed also (e.g., Spelke, Hirst, & Neisser, 1976). Extended practice beyond the point of "mastery" when performance is already largely "automatic," that is, overlearning, very likely continues to have effects (e.g., Bahrick, 1982). Theoretically, these effects in memory should show up as continued reduction in response times even after the trial of last error, reduced forgetting over long intervals as measured by savings methods (Ebbinghaus, 1885/1964; Nelson *et al.,* 1979), or as increases in the difficulty of the secondary task that can simultaneously be performed along with the primary task. Any of these findings would constitute evidence that events that do not require attention are nevertheless stored.

The question of attention-dependent versus attention-independent storage is related to the more general issue of whether there is a separate "memory mechanism" that is added to perceptual or self-generated experience in order to "store" it. That is, do we perceive and think by some mechanisms and have memory established by others (e.g., a "Now Print" mechanism, Brown & Kulik, 1977)? In MEM, the processes that produce perception and thought result in changes in potential future perception and thought (i.e., produce entries); there is no separate storage mechanism.

2. *Priority of Access*

An important issue for memory theories is specifying conditions affecting the relative availability of entries, and predicting the situations in which we are influenced by some but not other entries. For example, one task for theories of *attention* is to specify the mechanisms by which some entries recruit attention while others do not (the problem of "selection"). Models of attention have tended to concentrate on selectivity of response to external stimuli during ongoing perception or comprehension. However, it is equally important to account for selectivity of response to internally cued activation during less perceptual tasks such as reminiscing. In MEM, information from all memory subsystems is presumed to produce activated memory, but these entries are not equal in their ability to recruit attention; this varies with characteristics of the entries, characteristics of the test context, and the state of the subject.

Access to attention is greatly affected by the general circumstances during remembering. For example, if you close your eyes and try to remember a specific event, for example, a party that you attended recently, the recollection will very likely be dominated by what you did and thought rather than by what you saw and heard (assuming, of course, that you were an active participant during the party) (Johnson, Raye, Foley, & Foley, 1981;

Keenan *et al.*, 1977; Raye, Johnson, & Taylor, 1980; Slamecka & Graf, 1978). Activated information from the reflection system has priority, indicated by the darker shading in Fig. 1. Information from the perceptual system has somewhat less priority, and information from the sensory system is still less able to gain attention, or can only do so under special circumstances.

Of course, attention can be recruited by a sufficiently "rich" perceptual record. And, of course, perceptual input at the time of the memory test would also increase the availability of the perceptual record; hence, recognition tests are typically more sensitive than recall tests to physical features of events. Also, increasing the salience of perceptual features by making targets and distractors more similar may improve recognition under some circumstances (Tulving, 1981), as may activating related perceptual information in memory (Malpass & Devine, 1981). However, in the absence of specific perceptual stimuli, as is often the case during recall, our consciousness is dominated by the reflection record. It is not that sensory and perceptual information fades, but rather, according to MEM, that it is inhibited by information from the reflection system. The sensory and perceptual systems are "low-access" systems to voluntary processes. Under some conditions, the inhibition from the reflection system might be lifted, allowing entries from sensory and perceptual systems to have more influence, and perhaps accounting for sudden vivid recollections (Salaman, 1970), eidetic imagery (Stromeyer & Psotka, 1970), and some aspects of hypnagogic images, dreaming, and hallucinations.

The idea that one aspect of cognition might inhibit another has, of course, been suggested by many investigators working on various problems (e.g., Freud, Hughlings-Jackson, and Pavlov). The general concepts of excitation and inhibition have been basic building blocks in a number of theories of cognitive function. The mechanisms by which attention is recruited are probably related to quantitative changes in patterns of excitation and inhibition (e.g., changes in intensity, or marked dispersion or specificity of activation).

G. Stability of Entries

1. Time-Dependent Processes

There are two time-dependent processes that have been important in theorizing about memory, decay and consolidation. The multiple-entry model does not assume that memories decay. Aside from brain damage, storage is essentially permanent.

Similarly, MEM assumes that beyond the relatively short time it takes for chemical processes in the brain to respond to present external and internal events, memories do not further consolidate. Electroconvulsive shock or certain drug treatments have been administered to animals in order to disrupt a hypothetical consolidation process. However, there is some evidence of spontaneous recovery after such treatments and some evidence that "unconsolidated" memories are made more available by reminders (e.g., Spear, 1973). These results are consistent with the view presented here that whatever has been processed has created entries. Furthermore, improvements in performance without further stimulus input that suggest a consolidation process, for example, reminiscence and hypermnesia, would be the byproduct of further processing (e.g., rehearsal or revival) (cf. Roediger & Payne, 1982) that would not necessarily involve attention.

2. *Integration*

Some investigators assume that successive external events that are related create an integrated representation that *replaces* the individual representations (e.g., Bransford & Franks, 1971; Loftus, 1975; Loftus, Miller, & Burns, 1978). In contrast, the multiple-entry model proposes that *both* the earlier, individual representations and the integrated, constructed information produced by reflection are entered in memory (Johnson & Raye, 1981). Earlier memory entries are not lost by virtue of having been included in a construction (e.g., Beckerian & Bowers, 1983). This point can be illustrated by considering our everyday use of cognitive maps. Suppose that you learn your way from your hotel to the conference center by a "route map" in a strange town. Later, you find your way to the zoo and imagine a "survey map" that puts the hotel, conference center, and zoo all in relation to each other. If subsequently, someone asks you the way to the drugstore, which is located between your hotel and the conference center, you would not necessarily access your new comprehensive survey map of the area, but might well access your earlier, more restricted, but still sufficient-for-the-task route map. From the present view, research on conditions affecting the relative dominance of perceptually derived and reflectively generated information would be interesting.

3. *Mechanisms of Forgetting*

Assuming that decay and integration are not the major mechanisms of forgetting, what are? There are many potential mechanisms for forgetting in a system with essentially stable entries. For example, as previously discussed, confusion between the perceived and the imagined (failures in reality monitoring) can introduce distortion and inaccuracy in remembering (Johnson & Raye, 1981). Interference processes, such as competition and blocking from more dominant memories within subsystems (McGeoch, 1932) or inhibition from activation from other subsystems, could produce omissions and intrusions. Clearly, without loss or degrading of entries, forgetting occurs when the appropriate stimulus conditions are not recreated (McGeoch, 1932; Tulving & Thomson, 1973). In fact, it could be argued that other mechanisms of forgetting are special cases of failure to reinstate appropriate stimuli. For example, consider the case of response competition. Most investigators would agree that responses are associated with functional rather than nominal stimuli. Consequently, apparent competition between two different responses to the "same" nominal stimulus may reflect cue-dependent forgetting (e.g., failure to activate the appropriate interpretation of a stimulus) rather than direct competition between nominal responses (e.g., Hasher & Johnson, 1975; Hashtroudi & Johnson, 1976).

The critical point is that entries can be relatively stable and yet the system can yield imperfect memory. Interference may occur at many levels. It may be quite general (as when one system recruits attention at the expense of another), more specific (as when some entries have an advantage over others within the same subsystem), or even more specific (as when one set of entries associated with a stimulus are overshadowed by another set associated with a similar stimulus configuration). Furthermore, in MEM, activation of entries within any particular subsystem depends largely on the degree to which present stimulus conditions match those coded in the memory entries. Finally, not all tests are equally sensitive to information stored in memory (e.g., Bahrick, 1967; Johnson, 1977; Nelson, 1978), nor (as emphasized here) are they equally revealing about characteristics of different functional subsystems.

H. The Concept of an "Entry" versus the Concept of "The Trace"

Memory theorists often talk about "the trace." For most, this is a shorthand way of referring to whatever unknown physiological changes underlie changes in behavior produced by experience. At this extremely abstract level, there is not much disagreement that traces exist. However, the concept of a memory trace has been often challenged, primarily because traces tend to be thought of as "copies" of external events. Furthermore, the concept of trace tends to be associated with "episodic tasks" rather than "semantic tasks." The recent surge of interest in knowledge, skill learning, and strategies—the sorts of products of memory that do not appear to be mediated by a *single* episodic experience—has lead some investigators to look for some metaphor to replace the idea of a trace (e.g., Bransford, McCarrell, Franks, & Nitsch, 1977).

While there may be general consensus in the field that it is not fruitful to speak of "the" trace, this does not mean that there is not "any" trace. The point here is similar to Pavlov's (1932) criticism of Lashley. Lashley (1930) reported a series of studies showing that rats found mazes more difficult to learn in proportion to the amount of their cerebral hemispheres that had been destroyed. Lashley used these data to deemphasize functions of specific cortical areas in favor of a principle of mass action. Pavlov found Lashley's conclusion "original" but "quite inconceivable." He pointed out that different receptor systems (olfactory, auditory, visual, cutaneous, kinesthetic) are located in different parts of the cerebral hemispheres (along with possible dispersion of elements from each system throughout the entire mass of the hemispheres). If the rat draws on all of these receptors in learning the maze, then destroying any or several of them will hurt performance, and in proportion to the number destroyed. But it does not follow that there are no specific entries anywhere. The multiple-entry model assumes a similar distinction between localization topologically and localization within functional memory subsystems.[4]

According to the multiple-entry model, all events are complex and therefore entries are potentially formed in a number of subsystems (sensory, perceptual, reflection). Our subjective experience when we are remembering depends on the particular combination of information from all of these subsystems that reaches activation and, most importantly, attention, at any given moment. The fact that our subjective experience is a blend of these factors (i.e., "cross-modal") does not mean that different single entries do not exist.

Many investigators have emphasized the integrated, holistic qualities of memories. However, we know that the memory trace for an event is not typically unitized in any technical sense; revival of one type of information

[4]While sensory, perceptual, and reflection subsystems may not be localized in different places, they might be mediated by different types of structures or processes in the brain. Also, you might expect different species to have characteristically different relative distributions of these structures. Thus, a species that was good at recognition would not necessarily be good at recall and vice versa. It might even be some advantage in accessing sensory and perceptual entries to have relatively little competition from reflection entries (Shettleworth, 1983). However, there is no reason to believe that the selective pressures that produced the evidently "higher" reflection functions would eliminate the structures upon which the sensory and perceptual records and functions depend. In fact, a "multiple-entry" memory would be extremely valuable. Redundant information is, of course, less vulnerable. Furthermore, a malfunction in one system could perhaps be partially compensated for by the continued functioning of other processes and records.

(e.g., semantic) does not necessarily result in revival of other information (e.g., graphemic). That is, all features are not equally good redintegrative cues for the whole event, nor are events remembered "all or none." Even at the same apparent "level," not all aspects of a memory are activated at once (Loftus, 1982). Thus, events must create functionally distinct codes (Posner, 1978) or levels (Craik & Lockhart, 1972) or entries (the present model). We should keep in mind the distinction between the *phenomenology* of memory, where information from various sources is integrated and gestalt-like, and the *mechanisms* of memory, which may include functionally separate systems. In this regard memory is like perception: if we fell in a pigsty, we would have a unified experience, but we would not seriously mean that there were no differences in the mechanisms of seeing, smelling, touching, and hearing that go into that "holistic" experience.

One advantage of thinking in terms of subsystems is that it helps us imagine the independent operation of different aspects of memory. This potentially may help us organize such diverse facts as the independence of recall and recognition (Flexser & Tulving, 1978), improvement of amnesics on motor tasks that they do not remember engaging in previously (e.g., Milner, 1965), and the apparent dissociation between changes in reported fear and changes in responses to feared objects (Lang, 1969).

In sum, there is not one trace from a complex event, but multiple "entries." This is how memory derives its redundancy and flexibility. I have introduced the term "entry" rather than "trace" to avoid the connotation of an exclusive concern with externally derived information. In fact, a major emphasis of the present model is that self-generated information is a pervasive and powerful source of entries.

III. The Multiple-Entry Model and Other Theoretical Issues

A. Memories as Records of Complete Experiences

There is a tendency for researchers to characterize memory representations in terms of abstractions such as "information" or "propositions." The general idea is that memory representations consist of a "deep structure" for events, rather than the events themselves. While useful hypotheses follow from this approach, such abstractions tend to divorce memories from the mechanisms by which they were established. The multiple-entry model adopts the opposite approach emphasized by Johnson and Raye (1981): memory reflects the origin of information. Memory entries are the records of the specific processes that created the entries (Kohlers, 1975). Insofar as different events engage different processes (e.g., seeing a word versus hearing it versus thinking of it), the memory entries will be different. There is nothing "beyond" the record of these processes that "is" the memory representation.

In addition, cognitive models tend to paint a picture of a complex but essentially actionless and emotionless subject. However, memory is not composed simply of "pure" perceptions and thoughts, but includes actions and feelings as well. The simplest events involve movements and feelings (if only eye movements and boredom). Furthermore, actions and feelings are not transient. We are changed (perhaps permanently) as a consequence of their having happened. For example, such things as posture and mood are part of an event and may influence our ability to recollect the rest of the event just as "semantic" cues do (Bower, 1981; Rand & Wapner, 1967). Therefore, an argument could be made that action and feeling cannot simply be grafted onto a finished cognitive model, but should be part of its ongoing development. In MEM it is assumed that all subsystems are involved with the initiation and maintenance of movement and with the experience and "reexperience" of emotion. However, it is further proposed that the various subsystems play different roles in action or in emotion. For example, as mentioned earlier, certain types of stimulus-driven movements may largely be controlled by entries in the sensory system. Movement in response to complex stimulus patterns, for example, a skilled musician reading a piece of music for the first time or a skilled artist drawing "from life," may primarily involve the perceptual system. Movement that is more generative, that is, it requires new organization and planning (e.g., choreographing a dance), is more likely to involve the reflection system as well (see Fig. 1). Of course, "control" can be exercised by two or three systems simultaneously, or pass from one to another in different phases of learning; however, entries are created and preserved whenever a subsystem has been involved. Similarly, emotion very likely is influenced by or interacts with all subsystems. Some further thoughts on emotion and memory are presented in the next section.

B. Emotion

Zajonc (1980) has suggested that affect does not depend on "semantic" processing. Evidence supporting this idea is that preference judgments can be made more quickly than recognition judgments and that preferences build up with repeated exposure even when the subject does not recognize that the stimulus has occurred before. However, as Lazarus (1982) has pointed out, if a serial stage view of information processing (in which meaning is the end product of a complex sequence of transformations) is rejected, it is easier to see how cognition could be implicated in emotion with the immediacy and lack of awareness that is seemingly required. In terms of the present model, Zajonc's results suggest that emotion may be differentially associated with the memory subsystems. In fact, many emotional responses do seem strongly associated with information in the sensory and perceptual systems. In these cases, related information from the reflection system typically produces less emotion when it gains attention. Therefore, when we voluntarily recall an event, it often has a muted emotional quality. On the other hand, when we see something that reminds us of the event, such as a person involved, or the room where the event took place, we sometimes feel overcome by what appears to be a recreation of the initial emotional reaction.

What would be the functional value of such an arrangement? As Zajonc (1980) points out, "Before we evolved language and our cognitive capacities, which are so deeply dependent on language, it was the affective system alone upon which the organism relied for its adaptation" (p. 170). Clearly, it would be valuable to have an associative system that would initiate fear and running the moment a tiger came into view. At the same time, it would not be very functional if voluntarily thinking of a tiger created the same emotional responses. If you thought of a tiger while you were planting crops you might run off and hide; the crops would fail with obvious dire consequences.

One solution would be for evolution to select for an animal that simply did not think of tigers when they were not present; thus, inappropriate actions would not interfere with more functional, ongoing, activities. Another solution would be to select for an animal that could think of tigers without the full emotional responses that are associated with real tigers. The value of this second solution is that it would allow you to think of tigers in their absence in order to *plan* what to do when they are there (to build a safe hiding place, to invent a weapon). Such planning is one primary responsibility of the reflection system.

Thus, the ability to "dispassionately" contemplate events has its advantages (although people vary greatly in their ability to do so!). However, sometimes it is instructive, or useful therapeutically, to remember our emotional responses to specific events, objects, or people. There are probably more and less effective ways to help someone do this. For example, "Tell me how you felt when you realized you hurt his feelings," would probably be less successful than getting the person to first recreate the details of the event—"What was the look on his face when you said . . . ." Through revival of sensory-perceptual records, the original emotion often follows relatively automatically. Some emotions, although firmly entrenched in memory, are not easily accessed voluntarily.[5]

[5]"Delay of gratification" studies may make a similar point about the importance of sensory/perceptual stimuli for emotional-motivational responses (Mischel, 1981). The above discussion

On the other hand, certain emotions (e.g., some types of anxiety or depression) do not seem to fit the above description. They seem less affected by the presence or absence of specific, external stimuli, and more dependent on the nature of reflective activity. It is not that some emotions (e.g., fear) are inherently "in" the sensory system and others (e.g., depression) "in" the reflective system. For example, depression and anxiety can be elicited by actual dreadful circumstances as well as from our misconstrual of (and "compulsing over") objectively favorable circumstances (Sampson, 1981). However, thinking in terms of the MEM model suggests that methods of accessing and/or influencing feelings may depend on the primary entry system to which they are attached (cf. Lang, 1969).

C. Other Typologies of Memory

The memory system has been divided up in a number of ways in the last 20 years: into sensory buffers, short-term memory (STM), and LTM (Atkinson & Shiffrin, 1968); by levels of processing (Craik & Lockhart, 1972), or attributes (Bower, 1967; Underwood, 1969; Wickens, 1970); in terms of visual and verbal modes of representation (Paivio, 1971); into semantic and episodic memories (Tulving, 1972); and into the results of controlled and automatic processes (Shiffrin & Schneider, 1977).

The multiple-entry model explicitly differs from some of these views, for example, by denying the assumption of differential permanence of different types of information in Atkinson and Shiffrin (1968), Craik and Lockhart (1972), and Shiffrin and Schneider (1977). With respect to other ways of characterizing the memory system, MEM is more orthogonal than contradictory. For example, the dual code hypothesis proposes that there are functionally separate verbal and visual memory systems (Paivio, 1971). The multiple-entry model emphasizes a different organization of events. That is, words can be generated internally or perceived from external sources. In both cases, they will have linguistic properties. Similarly, pictures may be perceived or they may be generated (imaged), and in both cases they will have pictorial properties, for example, spatial characteristics (Kosslyn, 1980). However, according to MEM, perceived words and perceived pictures have something in common as well, their external source and dependence on perceptual processing for establishing representational

---

Footnote 5 (*continued*)
is related to the general issue of what makes a cognition "hot" (Abelson, 1963). Apparently it is concreteness or specificity, at least in part. That is, a person is not so much angered by abstractions such as "communism," as at their bohemian son who lives in a dusty house with a lot of other people.

entries. Likewise, generated words and generated pictures have something in common, their occurrence in the absence of perceptual stimuli and their control via reflection mechanisms. Thus, depending on the theoretical problem being addressed, at one time the visual qualities of an entry might be important, and at another time its perceptual origin might be important. To fully specify a "complete memory," many aspects would have to be taken into account (e.g., Underwood, 1969). However, it does seem possible to make progress in understanding memory by pursuing the implications of each of several different ways of characterizing the memory system.

The multiple-entry model is also orthogonal to the distinction between semantic and episodic memory (Tulving, 1972). However, how MEM and the semantic–episodic distinction might fit together will be considered in the next two sections to help clarify additional ideas embodied in the present model.

Finally, MEM is particularly compatible with recent work emphasizing that memory should not be equated with "awareness" (e.g., Jacoby & Witherspoon, 1982), nor with "effort" (Hasher & Zacks, 1979), and with approaches that characterize memory in terms of functional systems rather than in terms of global capacities (Spear, 1983).

1. Generic Memory and the Problem of Abstraction

There are at least two possible meanings of "semantic." First, the term semantic may denote having to do with word meanings. Second, the term semantic is sometimes used to refer to our knowledge of other types of meaning relations as well. In the multiple-entry model, meaning of this second sort is distributed throughout all subsystems, and is not exclusively associated with one (e.g., a conditioned emotional response is meaningful). As Hintzman (1978) points out, "generic" memory is probably a better name for what most people (including Tulving, 1972) mean by "semantic" memory, because most do not limit it to word meanings but include other sorts of general knowledge (e.g., days are shorter in winter, strategies for solving problems, etc.).

In the present framework, generic memories are created by sensory, perceptual, and reflection functions. The knowledge represented by generic memories would not all be available to introspection. Generic memories consist of well-learned, or readily inferred information; by definition, they are summations across two or more episodes. They include the rules, schemata, prototypes, and modal or averaged information that create "classes" or "categories" of events. Perhaps, as Wickelgren (1981) has suggested, all memories are on a continuum of generic memory; others have made a similar suggestion that generic and episodic memories represent different types of knowledge rather than separate memory systems (McCloskey & Santee, 1981).

A major problem in understanding generic memory is the process of abstraction (Brooks, 1978; Herrnstein & deVilliers, 1981; Mervis & Rosch, 1981). How are concepts and schemata created? In the present framework, it seems reasonable to assume that abstraction results from both sensory-perceptual and reflective processes. Some abstraction will be the by-product of perceptual experience, based, for example, on frequency of occurrence, stimulus generalization, and the overlap of activation of features or relations upon repeated experience with similar events. Such schemata are created by processes that are more automatic than consciously constructive. We might call this "perceptual abstraction." In contrast, other schemata are created by processes that are more consciously constructive. These abstractions will be the product of reflection, the self-generative processes that involve active search, comparison, analysis, and criticism ("reflective abstraction"). From the present point of view, neither type of abstraction replaces the specific, episodic memories on which they are based, but either might typically be more accessible than any specific episodic memory.

What is particularly interesting from the present perspective is the possibility that abstractions created perceptually and those created reflectively might have characteristically different properties, and might be activated by different types of cues. Such a difference might help explain why consciously constructed and maintained views or schemata (e.g., theories) often seem resistant to counterexamples, and, conversely, why unconsciously abstracted generalized reactions (e.g., fear of furry animals) often seem resistant to argumentation. The optimum strategy for changing a schema might depend on whether it is largely perceptually, or largely reflectively, based.

2. *Episodic versus Personal Memory*

In MEM, episodic memories are also created by all subsystems. Episodic memories are the consequences of unique experiences; each is distinctive by virtue of the complex activation pattern created when it was established (Hintzman, 1976). As Tulving pointed out, part of what makes a memory seem episodic rather than semantic is that we can remember the time and place the event occurred (e.g., the word "table" occurred on List A in the cognition laboratory a few minutes ago). These sorts of contextual features of episodic memories have sometimes been treated as the defining features of episodic memories and are at least emphasized by most investigators.

However, a memory may seem episodic even if not well localized in time and place, for example, when a face in a crowd seems suddenly familiar, the familiarity may arise from the distinctive features of the face, not from the identification of the time and place where it was previously experienced. Similarly, you might suddenly be reminded of a dream that you had sometime in the past, and have a vivid sense of some highly particular image, and yet have no idea when and where the dream occurred. (In fact, you may wonder if the image did not come from a painting rather than a dream, after all.) These are instances of what it seems reasonable to call episodic memories; the sense that they are derived from particular episodes gives us the feeling that we *should* be able to recall when and where they were previously experienced. However, their familiarity and unique, "episodic" character is not dependent on such contextual information. (Déjà vu—the sense of having experienced something before—is an instance of memory that seems specifically "episodic" while time and place information escape us.)

What makes a memory "personal" rather than simply episodic? Here the identification of time and place clearly play an important role. However, temporal and spatial information comprise only a subset of a more general class of associated information that may *personalize* a memory. According to MEM, this more general class of information is created by reflection activities. These are activities that go beyond immediate perceptual processes. They serve to identify relations among events from the past and the anticipated future of an individual.

A particularly important function of the reflection system is that it helps create and maintain personal identity or a sense of "self." For example, creating plans, initiating action, and evaluating events in relation to plans are the sorts of activities that differentiate the self from the outside world. They define the self as a locus of power or energy, as a constant in time and space, as an object in relation to other objects. Consider two different situations. In Situation A, you anticipate getting hungry, look for food, prepare it, become hungry, and eat the food. In Situation B, food magically appears on a random schedule often enough so that you are physically satisfied most of the time. In Situation A, you become an agent acting in and on the world, with some degree of control over your destiny. In Situation B, the food is happening to you—it is externally derived and you play no role in bringing it into existence. Anticipation is not necessary; feedback loops between acts and consequences are not established (Miller, Galanter, & Pribram, 1960). The ability to obtain food, and whatever specific skills and general competence that implies, does not become part of your "self-schema" (Markus, 1977).

In addition to defining the self in relation to possible acts and consequences, plans serve another important function—they *order* events. Suppose that you had to determine the relative order of getting hungry and obtaining food in the two situations above. It would be much easier to do this in the case where the two events occurred in the context of a planned sequence than in the case where they did not.

A similar case could be made for other reflective activities such as searching, comparing, criticizing, and plotting. They relate present events to the past and future. These reflective processes create a sense of continuity of experience by explicitly bridging gaps between distinct episodes.

What would happen if these reflective functions did not take place? Episodic memories would still be established in sensory and perceptual subsystems. Similarly, generic memories derived from these episodes via perceptual abstraction would continue to be established. However, the ability to voluntarily recall would be severely disrupted because recall depends greatly on reflection records. Those episodic memories that were remembered, for example, via recognition, while perhaps seeming distinctive or unique, would be difficult to localize in time and, especially, would not seem to have specific implications for the "self." They would not have been related to or embedded in a particular past or future. A pattern very much like this appears in some cases of clinical amnesia, the topic of the next section.

D. Amnesias

1. *Clinical Amnesias*

Differences in terminology, style of reporting, and the like make it difficult to fully integrate work on clinical amnesia and experimental work on memory (Schachter & Tulving, 1982a). However, a reasonable minimal requirement of a general memory model is that it not flagrantly contradict available clinical evidence. More desirable still, it would suggest particular ways of looking at memory dysfunction and help sharpen the discussion of theoretical issues. The present model can satisfy, I think, both of these criteria.

Amnesia may be produced various ways—a blow to the head, surgically induced lesions, brain damage associated with prolonged excessive drinking (Korsakoff's syndrome), and functional amnesias precipitated by traumatic personal events. Amnesias are commonly divided into two major types, retrograde and anterograde. Retrograde amnesia refers to forgetting events prior to the onset of amnesia; anterograde refers to disruption of memory for events that occur after the onset of amnesia. While it seems reasonable to suppose that both types of amnesia might be explained with a common mechanism (Wickelgren, 1979), there does seem to be some evidence that the severity of retrograde and anterograde amnesia are not necessarily correlated, and these two types of amnesia may sometimes reflect different mechanisms (Hirst, 1982; Moscovitch, 1982).

People with anterograde amnesia often have normal immediate memory spans: they can keep a reasonable number of unrelated items in mind as long as they can keep rehearsing them. However, after a short distraction, they may not be able to recall any of the information, or in fact, that they met the experimenter previously or engaged in a memory task.

This pattern of performance seemed at one point to implicate a failure to transfer information from STM to LTM (Atkinson & Shiffrin, 1968). The idea that transfer from STM to LTM was disrupted was what might be called a "strong encoding" hypothesis. It tacitly assumed that information is a homogeneous commodity flowing through the system. A block should therefore eliminate any memory in such a system.

However, evidence began to accumulate indicating that something of the experience was stored after all. For example, cues, either in the form of partially degraded stimuli or the first three letters of words, improve performance (Warrington & Weiskrantz, 1970). Furthermore, amnesics have shown improvement in tasks such as rotary pursuit, reading mirror images of words, identifying the objects in degraded pictures, and solving number sequences according to an addition rule (e.g., see Baddeley, 1982). These results are hard to interpret if one imagines a disruption in a flow of homogeneous information from short-term memory to long-term memory. Savings in these various tasks indicate that memories are created, even though subjects do not appear specifically to recall the sessions during which the memories were created.

A major alternative to the disruption of transfer theory is the retrieval deficit theory. Warrington and Weiskrantz (1970), for example, suggested that amnesics suffer during retrieval from increased proactive interference. The problems with the encoding versus retrieval distinction have been discussed by Tulving (1979; see also Kinsbourne & Wood, 1982). Basically, the point is that neither encoding nor retrieval can independently be assessed without the other.

The problem with trying to separate encoding from retrieval effects can be seen clearly in the present framework. Suppose a patient with Korsakoff's syndrome cannot recall but can recognize an event. This is not sufficient evidence to conclude that "the" memory is there and the problem is "merely" one of retrieval. The event may not have been encoded in such a fashion as to permit *recall* even in a normal person. That is, it may not have been entered by the reflection system. As long as it is reasonable to suppose that different memory tests draw differentially on different subsystems, the information that a particular test gives us about memory is specific to the subsystem that it draws upon.

A Reflection System Deficit. A kind of "encoding deficit" position makes sense if we consider the operations needed to engage a subsystem in the first place. That is, we can meaningfully speculate about deficits of encoding within a system if systems are defined in terms of these operations. In this context, it might, for example, be reasonable to propose that Korsakoff patients have relatively intact sensory and perceptual subsystems, but have an encoding deficit that is primarily associated with the reflection subsystem.

Consistent with this idea is the fact that people with Korsakoff's syndrome do not seem to be able to think of and describe strategies for remembering (Hirst & Volpe, cited in Hirst, 1982). When amnesics are required by an orienting task to respond semantically to target items, their performance is improved; but they do not benefit more than control subjects do (Cermak & Butters, 1973). From the present point of view, it is not surprising that inducing item-by-item semantic processing with an orienting task does not eliminate the difference between people with Korsakoff's syndrome and normal people. Normal people would be expected to engage in additional reflective activities that build relations among items or between items and other potential recall or recognition cues. That is, it would be difficult to fully equate the reflective activities engaged in by normal people and amnesics with an orienting task.

Proactive inhibition can also be viewed as an encoding deficit, that is, as a consequence of poor elaborators (Hasher & Johnson, 1975; Keppel, 1968; Postman & Underwood, 1973). There is some evidence that the quality of elaborators generated by subjects does decline under conditions of interference (Hasher & Johnson, 1975). Presumably, the search for effective elaborators that will withstand increasing interference from other items is an active, reflective process. Thus increased proactive inhibition in Korsakoff's patients would be expected.

In sum, the proposition here is that Korsakoff amnesics and other amnesics do not spontaneously engage in a range of reflection functions that create a reflection record like the one to which normals have voluntary access. A number of other recent suggestions for how to characterize the deficit that produces amnesia similarly converge on initial processing. For example, it has been characterized as a deficit in semantic processing (Cermak, 1977), a deficit in "strategic processing" (Crowder, 1982), a deficit in episodic processing (Kinsbourne & Wood, 1982), a deficit in distinctive encodings (Jacoby, 1982), a deficit in "vertical processes" (Wickelgren, 1979), and a deficit in initial learning (Huppert & Piercy, 1982). The localization of the deficit in the reflection subsystem would be consistent with many of these suggestions.

The same deficit that did not engage reflection functions at acquisition would not engage them on a memory test. Hence, even assuming that reflection could be induced at acquisition, a deficit might still be seen unless similar operations were induced at recall as well. That is, it is reasonable to suppose that within subsystems, some kind of encoding specificity holds (Tulving & Thomson, 1973). To reactivate an entry, you need a sufficient match between processes at acquisition and processes at test.

While a consensus seems to be developing that amnesics have particular problems with the kind of active processing that would be characteristic of the reflection system, in a recent review of the amnesic literature, Hirst (1982) seems to come to a quite different conclusion. Hirst places great weight on data suggesting that amnesics are particularly poor at judging the relative temporal order of events. Following Hasher and Zack's (1979) suggestion that temporal information is encoded automatically, Hirst proposes that automatic coding is disrupted in amnesics.

However, suppose that a substantial amount of temporal information is not "automatically" encoded in the sense that it is a fixed trace property. Suppose instead that temporal judgments depend also on memories created by earlier reflections. For example, temporal order between A and B would be specified if you remembered thinking of A when you saw B (when you saw the movie "Raiders of the Lost Ark," you thought that you liked it better than "Close Encounters") (cf. Hintzman, Summers, & Block, 1975; Tzeng, Lee, & Wetzel, 1979; Wickelgren, 1977). If you do not engage in that kind of comparative thinking, you will not later have available some potentially powerful temporal dating cues. Thus, I would draw just the opposite conclusion from that of Hirst: relatively automatic encoding (as evidenced by skill learning and perceptual learning) is more or less intact, but reflection functions (particularly strategic activities) are disrupted. The present argument depends, of course, on the idea that temporal judgments are often "derivative" from past or current reflection functions, and are not automatically encoded, simple properties of memory entries.

Why might someone cease making the sorts of connections illustrated by the movie example? There are several possibilities: (1) the associations that cause one episode (or idea) to activate another, or two episodes to be simultaneously activated by the same stimulus, may no longer exist; (2) the activation of related information may occur but not recruit attention; (3) attention may be recruited by related information, but additional reflective processes may not take place (e.g., elaboration or explicit comparison). Thus, the person may not try to figure out why one thing brought another to mind.

The second and third possibilities seem more plausible as explanations of amnesia than the first. However, the exact nature of the disruption still remains to be specified. For example, in (2), disruption in attention recruitment could be produced by unusually high background levels of activation, making it harder to detect any changes in activation (i.e., a Weber–Fechner function). Or if overall activity in the entire system were low, changes in activation patterns would generally fall below the threshold values necessary to engage attention, except perhaps for very well-learned information. Either of these possibilities would functionally disconnect attention from the sort of meaningful associations that go beyond the present stimulus, especially during remembering. On the other hand, disruption of reflective functions (3) without a deficit in attention recruitment may signal a malfunction of reflective functions specifically responsible for the covert manipulation of ideas.

The type of amnesia would depend on the specific nature of the disruption: (2) would produce both retrograde and anterograde amnesia, while (3) alone would produce only anterograde amnesia. If a breakdown in reflective activities developed gradually (as is very likely the case in patients with Korsakoff's syndrome), the result would be an "apparent" temporal gradient of retrograde amnesia. That is, increasing failure over a period of years to engage in reflective processing would produce a temporal gradient in recall that would appear to be a consequence of greater forgetting of more recent compared to more remote events (see also Butters & Albert, 1982). In any case, (1), (2), or (3), comparisons between present and past events would be unlikely. These sorts of comparisons normally embed an event in time and interweave it within the personal past. Without reflective activity, the event would not be recalled, and perhaps not recognized. If it did seem familiar later, it would not seem to have any connection with the self, or in Schacter and Tulving's (1982b) phrase, the memory would be "free floating."

2. *Childhood Amnesia*

A good deal of recent work in developmental psychology indicates that children are less likely than adults to engage in reflection functions in memory tasks (e.g., Brown, 1975; Kail, 1979). Or perhaps they engage in different reflection functions. In any event, in tasks that do not appear to depend so heavily on reflection, such as recognition or frequency judgments, children do quite well (Brown, 1975; Hasher & Zacks, 1979). In the present framework, because children do not set up the conditions for later voluntary retrieval, memories from childhood are relatively inaccessible ("childhood amnesia"). However, when these memories are activated by appropriate stimulus conditions (often specific physical stimuli such as Proust's madeleine), the memory may be intensely sensory (Salaman, 1970).

According to MEM, this intensity is because sensory aspects do not have as much competition in attention from associated reflection entries. The greater salience of sensory features in children's memories gives the impression that children's memories are "unschematized," while adults are "schematized" (e.g., Allport & Postman, 1947; Schachtel, 1947). From the present perspective, it would be more likely that in the adult the relatively "unschematized" entries from sensory and perceptual functions are suppressed, rather than nonexistent.

IV. Summary

This article presents a general framework for integrating memory research from a number of areas. The model is called "a multiple-entry, modular memory system" (MEM). It characterizes long-term memory as three distinguishable, though clearly interacting, subsystems: the sensory record, the perceptual record, and the reflection record. The phenomenal experience of remembering is created by the particular blend of information from these subsystems that reaches awareness. The multiple-entry model differs from certain other cognitive models in several ways: memory is not thought of as the last stage of a serial sequence of transformations but rather as the product of each of several processes; storage in memory does not depend on attention; and entries are permanent, including those that would be characterized in some models as "early stage" or "shallow," and therefore transient.

Not all tasks equally reveal what has been entered into the subsystems comprising memory. This helps to clarify certain controversies (e.g., between naive realists and naive constructivists) and helps to explain the independence among certain memory tasks, for example, recall, recognition, and perceptual threshold. I also suggested that the idea of partially modular subsystems is consistent with certain clinical findings, for example, agnosias and amnesias. I further proposed that a distinction should be made between episodic and personal memory: episodic memories (like generic memories) are created by all subsystems, whereas personal memory is largely created by the reflection system. A malfunction in the reflection system would tend to result in a disconnection between memories and personal identity such as is found in amnesics.

In addition a number of additional proposals were made: I suggested that generic memories, for example, abstractions and schemata, differ in the relative roles that perceptual versus reflective processes played in their development. Similarly, emotions differ in the extent to which they seem tied to perceptual events versus reflective events. Following this line of thought, I speculated that the most effective way to access or change schemas or emotions would depend on which subsystem was most involved.

Acknowledgments

Preparation of this article was supported by grants from the National Science Foundation (BNS 79-26145) and the National Institutes of Mental Health (MH 37222-01). I would like to thank the colleagues and students who read an earlier draft of the manuscript and provided comments and/or encouragement. I would especially like to acknowledge the helpful suggestions and criticisms of Evan Chua-Yap, Marvin Goldfried, Lynn Hasher, Shahin Hashtroudi, Julian Hochberg, Robert Liebert, Carol Raye, and Rose Zacks.

References

Abelson, R. P. Computer simulation of "hot cognitions." In S. Tomkins & S. Mesick (Eds.), *Computer simulation of personality*. New York: Wiley, 1963.

Alba, J. W. & Hasher, L. Is memory schematic? *Psychological Bulletin*, 1983, **93**, 203-231.

Allport, G. W., & Postman, L. *The psychology of rumor*. New York: Holt, 1947.

Atkinson, R. C., & Shiffrin, R. M. Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 2). New York: Academic Press, 1968.

Baddeley, A. Amnesia: A minimal model and an interpretation. In L.S. Cermak (Ed.), *Human memory and amnesia*. Hillsdale, New Jersey: Erlbaum, 1982.

Bahrick, H. P. Relearning and the measurement of retention. *Journal of Verbal Learning and Verbal Behavior*, 1967, **6**, 89–94.

Bahrick, H. P. *Maintenance of long-term ecological memory—methods and findings*. Paper presented at the annual meeting of the American Psychological Association, August 1982.

Bartlett, F. C. *Remembering: A study in experimental and social psychology*. London and New York: Cambridge Univ. Press, 1932.

Bates, E., Masling, M. & Kintsch, W. Recognition memory for aspects of dialog. *Journal of Experimental Psychology: Human Learning and Memory*, 1978, **4**, 187–197.

Bekerian, D. A., & Bowers, J. M. Eyewitness testimony: Were we mislead? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 1983, **9**, 139–145.

Bellezza, F. S., Cheesman, F. L., II, & Reddy, B. G. Organization and Semantic Elaboration in Free Recall. *Journal of Experimental Psychology: Human Learning and Memory*, 1977, **3**, 539–550.

Biederman, I., Rabinowitz, J., Glass, A., & Stacy, E. On the information extracted from a glance at a scene. *Journal of Experimental Psychology*, 1974, **103**, 597–600.

Bower, G. H. A multi-component theory of the memory trace. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation* (Vol. 1). New York: Academic Press, 1967.

Bower, G. H. A selective review of organizational factors in memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory*. New York: Academic Press, 1972.

Bower, G. H. Mood and memory. *American Psychologist*, 1981, **36**, 129–148.

Bower, G. H., Black, J. B., & Turner, T. J. Scripts in memory for text. *Cognitive Psychology*, 1979, **11**, 177–220.

Bransford, J. D., Barclay, R., & Franks, J. Sentence memory: A constructive versus interpretative approach. *Cognitive Psychology*, 1972, **3**, 193–209.

Bransford, J. D., & Franks, J. J. The abstraction of linguistic ideas. *Cognitive Psychology*, 1971, **2**, 331–350.

Bransford, J. D., & Johnson, M.K. Considerations of some problems of comprehension. In W. Chase (Ed.), *Visual information processing*. New York: Academic Press, 1973.

Bransford, J. D., McCarrell, N. S., Franks, J. J., & Nitsch, K. E. Toward unexplaining memory. In R. Shaw & J. Bransford (Eds.), *Perceiving, acting, and knowing*. Hillsdale, New Jersey: Erlbaum, 1977.

Broadbent, D. E. *Perception and communication*. Oxford: Pergamon, 1958.

Broadbent, D. E. *Decision and stress*. New York: Academic Press, 1971.

Brooks, L. Nonanalytic concept formation and memory for instances. In E. Rosch & B. B. Lloyd (Eds.), *Cognition and categorization*. Hillsdale, New Jersey: Erlbaum, 1978.

Brown, A. L. The development of memory: Knowing, knowing about knowing, and knowing how to know. In H.W. Reese (Ed.), *Advances in child development and behavior* (Vol. 10). New York: Academic Press, 1975.

Brown, R., & Kulik, J. Flashbulb memories. *Cognition*, 1977, **5**, 73–99.

Brunswik, E. *Perception and the representative design of psychological experiments* (2nd ed.). Berkeley, California: Univ. of California Press, 1956.

Butters, N., & Albert, M. S. Processes underlying failures to recall remote events. In L. S. Cermak (Ed.), *Human memory and amnesia*. Hillsdale, New Jersey: Erlbaum, 1982.

Cerella, J. Visual classes and natural categories in the pigeon. *Journal of Experimental Psychology: Human Perception and Performance*, 1979, **5**, 68–77.

Cermak, L. S. The contribution of a "processing" deficit to alcoholic Korsakoff patients' memory disorder. In I. M. Birnbaum & E. S. Parker (Eds.), *Alcohol and human memory*. Hillsdale, New Jersey: Erlbaum, 1977.

Cermak, L. S., & Butters, N. Information processing deficits of alcoholic Korsakoff patients. *Quarterly Journal of Studies on Alcohol*, 1973, **34**, 1110–1132.

Chase, W. G., & Simon, H. A. The mind's eye in chess. In W. G. Chase (Ed.), *Visual information processing*. New York: Academic Press, 1973.

Craik, F. I. M., & Kirsner, K. The effect of speaker's voice on word recognition. *Quarterly Journal of Experimental Psychology*, 1974, **26**, 274–284.

Craik, F. I. M., & Lockhart, R. S. Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, 1972, **11**, 671–684.

Craik, F. I. M., & Tulving, E. Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General*, 1975, **104**, 268–294.

Craik, F. I. M., & Watkins, M. J. The role of rehearsal in short-term memory. *Journal of Verbal Learning and Verbal Behavior*, 1973, **12**, 599–607.

Crowder, R. G. General forgetting theory and the locus of amnesia. In L. S. Cermak (Ed.), *Human memory and amnesia*. Hillsdale, New Jersey: Erlbaum, 1982.

Dorfman, D. *Recognition memory for the surface form of sentences in connected discourse*. Paper presented at the 50th annual meeting of the Eastern Psychological Association, Philadelphia, April, 1979.

Durso, F. T., & Johnson, M. K. Facilitation in naming and categorizing repeated pictures and words. *Journal of Experimental Psychology: Human Learning and Memory*, 1979, **5**, 449–459.

Ebbinghaus, H. *Memory: A contribution to experimental psychology*. New York: Dover, 1964. (Originally published 1885.)

Eich, E. *Memory for vs. awareness of unconscious events*. Paper presented at the annual meeting of the Psychonomic Society, Minneapolis, Minnesota, November, 1982.

Erdelyi, M. A new look at the new look. *Psychological Review*, 1974, **81**, 1–25.

Flexser, A. J., & Tulving, E. Retrieval independence in recognition and recall. *Psychological Review*, 1978, **85**, 153–171.

Foley, M. A., & Johnson, M. K. *The consequences for memory of imagining in another person's voice*. Paper presented at the annual meeting of the Eastern Psychological Association, April, 1982.

Forbach, G. B., Stanners, R. F., & Hochhaus, L. Repetition and practice effects in a lexical decision task. *Memory & Cognition*, 1974, **2**, 337–339.

Fowler, C. A., Wolford, G., Slade, R., & Tassinary, L. Lexical access with and without awareness. *Journal of Experimental Psychology: General*, 1981, **110**, 341–362.

Friedman, A. Framing pictures: The role of knowledge in automatized encoding and memory for gist. *Journal of Experimental Psychology: General*, 1979, **108**, 316–355.

Geiselman, R. E., & Bjork, R. A. Primary versus secondary rehearsal in imagined voices: Differential effects on recognition. *Cognitive Psychology*, 1980, **12**, 188–205.

Gibson, J. J. *The senses considered as perceptual systems*. Boston, Massachusetts: Houghton, 1966.

Glenberg, A., Smith, S. M., & Green, C. Type I rehearsal: Maintenance and more. *Journal of Verbal Learning and Verbal Behavior*, 1977, **16**, 339–352.

Goldmeier, E. *The memory trace: Its formation and its fate*. Hillsdale, New Jersey: Erlbaum, 1982.

Haber, R. N., & Hershenson, M. Effects of repeated brief exposures on the growth of a percept. *Journal of Experimental Psychology*, 1965, **69**, 40–46.

Hanley, G. L., & Levine, M. Spatial problem solving: The integration of independently learned cognitive maps. *Memory & Cognition,* in press.

Hasher, L., & Griffin, M. Reconstructive and reproductive processes in memory. *Journal of Experimental Psychology*, 1978, **4**, 318–330.

Hasher, L., & Johnson, M. K. Interpretive factors in forgetting. *Journal of Experimental Psychology: Human Learning and Memory*, 1975, **1**, 567–575.

Hasher, L., & Zacks, R. T. Automatic and effortful processes in memory. *Journal of Experimental Psychology: General*, 1979, **108**, 356–388.

Hashtroudi, S., & Johnson, M. K. Transfer and forgetting: Interpretive shifts and stimulus reinstatement. *Journal of Experimental Psychology: Human Learning and Memory*, 1976, **2**, 262–272.

Herrnstein, R. J., & de Villiers, P. A. Fish as a natural category for people and pigeons. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research theory* (Vol. 14). New York: Academic Press, 1980.

Hintzman, D. L. Repetition and memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 10). New York: Academic Press, 1976.

Hintzman, D. L. *The psychology of learning and memory*. San Francisco, California: Freeman, 1978.

Hintzman, D. L., & Summers, J. J. Long-term visual traces of visually-presented words. *Bulletin of the Psychonomic Society,* 1973, **1**, 325–327.

Hintzman, D. L., Summers, J. J., & Block, R. A. Spacing judgments as an index of study-phase retrieval. *Journal of Experimental Psychology: Human Learning and Memory*, 1975, **1**, 31–40.

Hirst, W. The amnesic syndrome: Descriptions and explanations. *Psychological Bulletin,* 1982, **91**, 435–460.

Hochberg, J. Perception 1. Color and shape. In J. W. Kling & L. A. Riggs (Eds.), *Woodworth & Schlosberg's Experimental psychology* (3rd ed.). New York: Holt, 1971.

Hochberg, J. On cognition in perception: Perceptual coupling and unconscious inference. *Cognition*, 1981, **10**, 127–134.

Huppert, F. A., & Piercy, M. In search of the functional locus of amnesic syndromes. In L. S. Cermak (Ed.), *Human memory and amnesia*. Hillsdale, New Jersey: Erlbaum, 1982.

Jacoby, L. L. On interpreting the effects of repetition: Solving a problem versus remembering a solution. *Journal of Verbal Learning and Verbal Behavior*, 1978, **17**, 649–667.

Jacoby, L. L. Knowing and remembering: Some parallels in the behavior of Korsakoff patients and normals. In L. S. Cermak (Ed.), *Human memory and amnesia*. Hillsdale, New Jersey: Erlbaum, 1982.

Jacoby, L. L., & Dallas, M. On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General*, 1981, **110**, 306–340.

Jacoby, L. L., & Witherspoon, D. Remembering without awareness. *Canadian Journal of Psychology*, 1982, **36**, 300–324.

Johnson, M. K. What is being counted none the less? In I. M. Birnbaum & E. S. Parker (Eds.), *Alcohol and human memory*. Hillsdale, New Jersey: Erlbaum, 1977.

Johnson, M. K., Bransford, J. D., & Solomon, S. K. Memory for tacit implications in sentences. *Journal of Experimental Psychology*, 1973, **98**, 203–205.

Johnson, M. K., Kahan, T. L., & Raye, C. L. *Dreams and reality monitoring*. Paper presented at the annual meeting of the Psychonomic Society, November, 1981.

Johnson, M. K., & Raye, C. L. Reality monitoring. *Psychological Review*, 1981, **88**, 67–85.

Johnson, M. K., Raye, C. L., Foley, H. J., & Foley, M. A. Cognitive operations and decision bias in reality monitoring. *American Journal of Psychology*, 1981, **94**, 37–64.

Johnson, M. K., Raye, C. L., Foley, M. A., & Kim, J. Pictures and images: Spatial and temporal information compared. *Bulletin of the Psychonomic Society*, 1982, **19**, 23–26.

Johnson, M. K. , Raye, C. L., Wang, A. Y., & Taylor, T. H. Fact and fantasy: The roles of accuracy and variability in confusing imaginations with perceptual experiences. *Journal of Experimental Psychology: Human Learning and Memory*, 1979, **5**, 229–240.

Julesz, B. *Foundations of cyclopean perception*. Chicago, Illinois: Univ. of Chicago Press, 1971.

Kahneman, D. *Attention and effort*. New York: Prentice-Hall, 1973.

Kail, R. *The development of memory in children*. San Francisco: Freeman, 1979.

Keenan, J. M., MacWhinney, B., & Mayhew, D. Pragmatics in memory: A study of natural conversation. *Journal of Verbal Learning and Verbal Behavior*, 1977, **16**, 549–560.

Kellogg, R. T. Is conscious attention necessary for long-term storage? *Journal of Experimental Psychology: Human Learning and Memory*, 1980, **6**, 379–390.

Keppel, G. Retroactive and proactive inhibition. In T. R. Dixon & D. L. Horton (Eds.), *Verbal behavior and general behavior theory*. New York: Prentice-Hall, 1968.

Kinsbourne, M., & Wood, F. Theoretical considerations regarding the episodic-semantic memory distinction. In L. S. Cermak (Ed.), *Human memory and amnesia*. Hillsdale, New Jersey: Erlbaum, 1982.

Kintsch, W. *The representation of meaning in memory*. Hillsdale, New Jersey: Erlbaum, 1974.

Kintsch, W., & Bates, E. Recognition memory for statements from a classroom lecture. *Journal of Experimental Psychology: Human Learning and Memory*, 1977, **3**, 150–168.

Kirsner, K., & Smith, M. C. Modality effects in word identification. *Memory & Cognition*, 1974, **2**, 637–640.

Kolb, B., & Whishaw, I. Q. *Fundamentals of human neuropsychology*. San Francisco, California: Freeman, 1980.

Kohlers, P. A. Specificity of operations in sentence recognition. *Cognitive Psychology*, 1975, **7**, 289–306.

Kosslyn, S. M. *Image and mind*. Cambridge, Massachusetts: Harvard Univ. Press, 1980.

Kowler, E., & Martins, A. J. Eye movements of preschool children. *Science*, 1982, **215**, 997–999.

Kunst-Wilson, W. R., & Zajonc, R. B. Affective discrimination of stimuli that cannot be recognized. *Science*, 1980, **207**, 557–558.

Lang, P. J. The mechanics of desensitization and the laboratory study of fear. In C. M. Franks (Ed.), *Behavior therapy: Appraisal and status.* New York: McGraw-Hill, 1969.

Lashley, K. S. Basic neural mechanisms in behaviour. *Psychological Review.*, 1930, **37**, 1–24.

Lazarus, R. S. Thoughts on the relations between emotion and cognition. *American Psychologist*, 1982, **37**, 1019–1024.

Levine, M. Hypothesis behavior by humans during discrimination learning. *Journal of Experimental Psychology*, 1966, **71**, 331–336.

Levine, M., Jankovic, I. N., & Palij, M. Principles of spatial problem solving. *Journal of Experimental Psychology: General*, 1982, **111**, 157–175.

Light, L. L., Kayra-Stuart, F., & Hollander, S. Recognition memory for typical and unusual faces. *Journal of Experimental Psychology: Human Learning and Memory*, 1979, **5**, 212–228.

Lindsay, P. H., & Norman, D. A. *An introduction to psychology* (2nd ed.). New York: Academic Press, 1977.

Loftus, E. F. Leading questions and the eyewitness report. *Cognitive Psychology*, 1975, **7**, 560–572.

Loftus, E. F. Remembering recent experiences. In L. S. Cermak (Ed.). *Human memory and amnesia*. Hillsdale, New Jersey: Erlbaum, 1982.

Loftus, E. F., Miller, D. G., & Burns, H. J. Semantic integration of verbal information into a visual memory. *Journal of Experimental Psychology: Human Learning and Memory*, 1978, **4**, 19–31.

Luria, A. R. *The working brain: An introduction to neuropsychology*. New York: Basic Books, 1973.

Malpass, R. S., & Devine, P. G. Guided memory in eyewitness identification. *Journal of Applied Psychology*, 1981, **66**, 343–350.

Mandler, G. Organization and memory. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation* (Vol. 1). New York: Academic Press, 1967.

Mandler, G. Recognizing: The judgment of previous occurrence. *Psychological Review*, 1980, **87**, 252–271.

Mandler, J., & Stein, N. Recall and recognition of pictures by children as a function of organization and distractor similarity. *Journal of Experimental Psychology*, 1974, **102**, 657–669.

Markus, H. Self-schemata and processing of information about the self. *Journal of Personality and Social Psychology*, 1977, **35**, 63–78.

McCauley, C., Parmelee, C. M., Sperber, R. O., & Carr, T. H. Early extraction of meaning from pictures and its relation to conscious identification. *Journal of Experimental Psychology: Human Perception and Performance*, 1980, **6**, 265–276.

McCloskey, M., & Santee, J. Are semantic memory and episodic memory distinct systems? *Journal of Experimental Psychology: Human Learning and Memory*, 1981, **7**, 66–71.

McGeoch, J. A. Forgetting and the law of disuse. *Psychological Review*, 1932, **39**, 352–370.

Merluzzi, T. V., & Johnson, N. F. The effect of repetition on iconic memory. *Quarterly Journal of Experimental Psychology*, 1974, **26**, 266–273.

Mervis, C. B., & Rosch, E. Categorization of natural objects. *Annual Review of Psychology*, 1981, **32**, 89–115.

Meyer, D. E., & Schvaneveldt, R. W. Meaning, memory structure, and mental processes. *Science*, 1976, **192**, 27–33.

Miller, G. A., Galanter, E., & Pribram, K. A. *Plans and the structure of behavior*. New York: Holt, 1960.

Milner, B. Memory disturbance after bilateral hippocampal lesions. In P. M. Milner & S. E. Glickman (Eds.), *Cognitive processes and the brain*. Princeton, New Jersey: Van Nostrand, 1965.

Mischel, W. Objective and subjective rules for delay of gratification. In G. D'Ydewalle & W. Lens (Eds.), *Cognition in human motivation and learning*. Hillsdale, New Jersey: Erlbaum, 1981.

Moray, N. Attention in dichotic listening. Affective cues and influence of instructions. *Quarterly Journal of Experimental Psychology*, 1959, **11**, 56–60.

Moscovitch, M. Multiple dissociations of function in amnesia. In L. S. Cermak (Ed.), *Human Memory and Amnesia*. Hillsdale, New Jersey: Erlbaum, 1982.

Neisser, U. *Cognitive psychology*. New York: Appleton, 1967.

Nelson, D. L. Remembering pictures and words: Appearance, significance, and name. In L. S. Cermak & F. I. M. Craik (Eds.), *Levels of processing in human memory*. Hillsdale, New Jersey: Erlbaum, 1979.

Nelson, T. O. Detecting small amounts of information in memory: Savings for nonrecognized items. *Journal of Experimental Psychology: Human Learning and Memory*, 1978, **4**, 453–468.

Nelson, T. O., Fehling, M. R., & Moore-Glascock, J. The nature of semantic savings for items forgotten from long-term memory. *Journal of Experimental Psychology: General*, 1979, **108**, 225–250.

Newell, A., & Simon, H. A. *Human problem solving*. New York: Prentice-Hall, 1972.

Nilsson, T. H., & Nelson, T. M. Delayed monochromatic hue matches indicate characteristics of visual memory. *Journal of Experimental Psychology: Human Perception and Performance*, 1981, **7**, 141–150.

Norman, D. A., & Bobrow, D. G. On data limited and resource limited processes. *Cognitive Psychology*, 1975, **7**, 44–64.

Paivio, A. *Imagery and verbal processes*. New York: Holt, 1971.

Pavlov, I. P. The reply of a physiologist to psychologists. *Psychological Review*, 1932, **39**, 91–127.

Peterson, M. J. The retention of imagined and seen spatial matrices. *Cognitive Psychology*, 1975, **7**, 181–193.

Posner, M. I. *Chronometric explorations of mind*. Hillsdale, New Jersey: Erlbaum, 1978.

Posner, M. I., & Keele, S. W. On the genesis of abstract ideas. *Journal of Experimental Psychology*, 1968, **77**, 353–363.

Postman, L., & Underwood, B. J. Critical issues in interference theory. *Memory and Cognition*, 1973, **1**, 19–40.

Rand, G., & Wapner, S. Postural status as a factor in memory. *Journal of Verbal Learning and Verbal Behavior*, 1967, **6**, 268–271.

Raye, C. L., Johnson, M. K., & Taylor, T. H. Is there something special about memory for internally-generated information? *Memory and Cognition*, 1980, **8**, 141–148.

Reber, A. S., & Lewis, S. Implicit learning: An analysis of the form and structure of a body of tacit knowledge. *Cognition*, 1977, **5**, 333–361.

Rock, I., & Gutman, D. The effect of inattention on form perception. *Journal of Experimental Psychology: Human Perception and Performance*, 1981, **7**, 275–285.

Roediger, H. L., & Payne, D. G. Hypermnesia: The role of repeated testing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 1982, **8**, 66–72.

Rothkopf, E. Z. Incidential memory for location of information in text. *Journal of Verbal Learning and Verbal Behavior*, 1971, **10**, 608–613.

Rundus, D. Maintenance rehearsal and single-level processing. *Journal of Verbal Learning and Verbal Behavior*, 1977, **16**, 665–681.

Sachs, J. S. Recognition memory for syntactic and semantic aspects of connected discourse. *Perception & Psychophysics*, 1967, **2**, 437–442.

Salaman, E. *A collection of moments*. London: Longman, 1970.

Sampson, E. E. Cognitive psychology as ideology. *American Psychologist*, 1981, **36**, 730–743.

Scarborough, D., Cortese, C., & Scarborough, H. Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance*, 1977, **3**, 1–17.

Schachtel, E. G. On memory and childhood amnesia. *Psychiatry*, 1947, **10**, 1–26.

Schacter, D. L., & Tulving, E. Amnesia and memory research. In L. S. Cermak (Ed.), *Human memory and amnesia*. Hillsdale, New Jersey: Erlbaum, 1982. (a)

Schacter, D. L., & Tulving, E. Memory, amnesia, and the episodic/semantic distinction. In R. L. Isaacson & N. E. Spear (Eds.), *The expression of knowledge*. New York: Plenum, 1982. (b)

Schank, R. C., & Abelson, R. *Scripts, plans, goals, and understanding*. Hillsdale, New Jersey: Erlbaum, 1977.

Schneider, G. E. Two visual systems. *Science*, 1969, **163**, 895–902.

Shettleworth, S. J. Memory in food-hoarding birds. *Scientific American*, 1983, **248**, 102–110.

Shiffrin, R. M., & Schneider, W. Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review*, 1977, **84**, 127–190.

Slamecka, N. J., & Graf, P. The generation effect: Delineation of a phenomenon. *Journal of Experimental Psychology: Human Learning and Memory*, 1978, **4**, 592–604.

Spear, N. E. Retrieval of memory in animals. *Psychological Review*, 1973, **80**, 163–194.

Spear, N. E. The future study of learning and memory from a psychobiological perspective. In V. Sarris & A. Parducci (Eds.), *Perspectives in Psychological Experimentation*. Hillsdale, New Jersey: Erlbaum, 1983, in press.

Spelke, E., Hirst, W., & Neisser, U. Skills of divided attention. *Cognition*, 1976, **4**, 215–230.

Sperling, G. The information available in brief visual presentations. *Psychological Monographs*, 1960, **74**, (Whole No. 498).

Stromeyer, C. F., III, & Psotka, J. The detailed texture of eidetic images. *Nature, (London)*, 1970, **225**, 346–349.

Tolman, E. C. There is more than one kind of learning. *Psychological Review*, 1949, **56**, 144–155.

Treisman, A. M., & Gelade, G. A feature-integration theory of attention. *Cognitive Psychology*, 1980, **12**, 97–136.

Treisman, A. M., & Schmidt, H. Illusory conjunctions in the perception of objects. *Cognitive Psychology*, 1982, **14**, 107–141.

Tulving, E. Theoretical issues in free recall. In T. R. Dixon & D. L. Horton (Eds.), *Verbal behavior and general behavior theory*. New York: Prentice-Hall, 1968.

Tulving, E. Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory*. New York: Academic Press, 1972.

Tulving, E. Relation between encoding specificity and levels of processing. In L. S. Cermak & F. I. M. Craik (Eds.), *Levels of processing in human memory*. Hillsdale, New Jersey: Erlbaum, 1979.

Tulving, E. Similarity relations in recognition. *Journal of Verbal Learning and Verbal Behavior*, 1981, **20**, 479–496.

Tulving, E., & Thomson, D. M. Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, 1973, **80**, 352–373.

Turvey, M. T. Repetition and the preperceptual information store. *Journal of Experimental Psychology*, 1967, **74**, 289–293.

Tversky, B. Encoding processes in recognition and recall. *Cognitive Psychology*, 1973, **5**, 275–287.

Tyler, S. W., & Ellis, H. C. A test of alternative models of sentence recognition. *Bulletin of the Psychonomic Society*, 1978, **12**, 375–377.

Tyler, S. W., Hertel, P. T., McCallum, M. C., & Ellis, H. C. Cognitive effort and memory. *Journal of Experimental Psychology: Human Learning and Memory*, 1979, **5**, 607–617.

Tzeng, O. J. L. Sentence memory: Recognition and inferences. *Journal of Experimental Psychology: Human Learning and Memory*, 1975, **1**, 720–726.

Tzeng, O. J. L., Lee, A. T., & Wetzel, C. D. Temporal coding in verbal information processing. *Journal of Experimental Psychology: Human Learning and Memory,* 1979, **5**, 52–64.

Underwood, B. J. Attributes of memory. *Psychological Review*, 1969, **76**, 559–573.

Warrington, E. K., & Weiskrantz, L. Amnesic syndrome: Consolidation or retrieval? *Nature (London)*, 1970, **228**, 628–630.

Weiskrantz, L., Warrington, E. K., & Sanders, M. D. Visual capacity in the hemianopic field following a restricted occipital ablation. *Brain*, 1974, **97**, 709–728.

Wickelgren, W. A. *Learning and memory*. New York: Prentice-Hall, 1977.

Wickelgren, W. A. Chunking and consolidation: A theoretical synthesis of semantic networks, configuring in conditioning, S-R versus cognitive learning, normal forgetting, the amnesic syndrome, and the hippocampal arousal system. *Psychological Review*, 1979, **86**, 44–60.

Wickelgren, W. A. Human learning and memory. *Annual Review of Psychology*, 1981, **32**, 21–52.

Wickens, D. D. Encoding categories of words: An empirical approach to meaning. *Psychological Review*, 1970, **77**, 1–15.

Wilson, W. R. Feeling more than we can know: Exposure effects without learning. *Journal of Personality and Social Psychology*, 1979, **37**, 811–821.

Woodworth, R. S. *Experimental psychology*. New York: Holt, 1938.

Zajonc, R. B. Feeling and thinking: Preferences need no inferences. *American Psychologist*, 1980, **35**, 151–175.