Psychology in the 1990's
K.M.J. Lagerspetz and P. Niemi (Editors)

MULTIPLE LEARNING AND MEMORY SYSTEMS

Endel Tulving
University of Toronto, Canada

In this essay an ideational projection into the future is made in the form of a prediction that students of learning and memory will discover and verify the existence of multiple learning and memory systems. Until recently the majority of researchers have held the pretheoretical belief that a single system underlies all phenomena of learning and memory. The single-system idea is now under intensive experimental and theoretical scrutiny, and its revision seems to be imminent. This change is fueled by increasingly persuasive findings of sharp dissociations in various kinds of learning and memory performance observed in patients with organic brain damage, in experimentally lesioned animals, and in normal human subjects. Initial suggestions have already been made that some dichotomies and trichotomies of learning and memory that have been proposed in fact represent distinct neurobehavioral and neurocognitive systems. The discovery and verification of the existence of such postulated multiple systems will result from the collective and collaborative efforts of researchers in neurophysiology, neuropsychology, and psychology, as well as other disciplines, and will lead to the emergence of a new science of learning and memory.

Language makes possible transmission of knowledge within and between generations and thereby plays an exceedingly crucial role in the development of the species of **homo sapiens.** Without it civilization as we know it would not exist. But while language is admirably suited for conducting the practical affairs of men, its blessings come at a price in certain spheres of human activity. The cost is especially

heavy in the pursuit of new knowlege by means of the methods of science: the language scientists initially adopt to describe phenomena of interest frequently becomes an unsuspected source of difficulty in creative thought and an obstacle on the path of progress. It took physicists over a hundred years to distinguish between heat and temperature (Holton & Brush, 1973), and biologists over two hundred to give up the futile search for the solution of the life-matter problem (Hall, 1969). Such slow progress can at least partly be attributed to the pre-existing ideas and the words used to express them. The discipline known as psychology is full of similar Procrustean terms that force the reality into inflexible, even if fuzzy, categories.

"Psychology" itself is an umbrella term that covers a number of rather different areas of scientific pursuit. At the very least, it subsumes two quite sharply distinguishable disciplines, one of behavior and the other of the mind. Although they share some accidental historical roots, the science of behavior has little to do with the science of the mind. Study and understanding of behavior is perfectly possible without any reference to the mind, and although psychological study of the mind requires observation of behavior, its understanding is neither greatly aided nor hampered by any knowledge of the principles that govern the lawfulness of behavior. The idea that the two sciences are one and the fond hope that a general theory of behavior and experience is possible only testify to psychologists' respect for tradition and their love of unity and harmony in the universe. There is little rational basis for it.

It can be argued that psychology comprises more than just two separate disciplines. These disciplines have at present little of substance in common. They differ not only with respect to their subject matter, nature of questions they pose, and the methods they use, but also with respect to the reliability of their facts and the sophistication of their theoretical accomplishments. For instance, analysis of behavior of individuals in a group is no more affected by principles of psychophysics

than the principles of astrophysics; personality theory can as safely ignore facts of biopsychology as it can ignore facts of cognitive psychology.

If it is true that a unified science of psychology exists only as a figment of imagination in the minds of people who believe that unity of any kind is intrinsically valuable, predictions about psychology or psychological theory as a whole are difficult if not impossible. If we wish to speculate about the future, we would do well to restrict our attention to individual disciplines of the broad field of psychology. This is what I do in this essay: I discuss one aspect of the future of the scientific study of learning and memory.

Let me begin what might be regarded as a prediction but in fact represents only a projection into the future of certain present developments. The projection is this: students of memory will discover the existence of a number of different learning and memory systems that possess the capabilities of operating independently as well as in conjunction with one another in the production of the large variety of phenomena of learning and memory with which we are already familiar, and an even larger variety of phenomena still to be discovered.

The discovery will lay to rest the ideas, originally well meant but now apparently wrong, that a single learning and memory system mediates the behavioral and experiential plasticity of human beings, and other higher animals, and that all phenomena of learning and memory in a species reflect the many ways in which the single system works.

In what follows, we will briefly consider the origin and current status of the idea of unitary learning and memory, examine the reasons why the abandonment of the idea is now indicated, summarize some of the suggestions that have been made with respect to multiplicity of learning and memory systems, and mention some of the defining features of such systems.

ONE LEARNING, ONE MEMORY

People and other organisms are capable of learning a virtually infinite variety of things, under a very large number of different conditions, and do so with highly variable degrees of facility and success. This large variability - in what organisms can learn and retain, in the manner in which they do it, and in the ways in which they use what they have learned and retained - has provided students of learning and memory with a rich data base to work with, as well as a tremendous theoretical challenge: How can we explain the what and how of learning and memory? The ultimate objective of the enterprise has almost invariably been taken to be the construction of a single, comprehensive theory of learning, or of memory, that would cover all known phenomena in the domain of the theory. The rationality, or reasonableness, of such an objective has only seldom been questioned. Instead, the dominant underlying assumption throughout the history of thought and research on learning and memory has been the same: The basic mechanism of learning and memory is one. A representative statement is the following: "All learning is essentially of a kind - the modification of behavior as the result of repeated stimulation under specified conditions"(Hunter, 1934; p. 514). When alternative suggestions have been made (e.g., Tolman, 1949), they have been usually summarily rejected (e.g., McGeoch and Irion, 1952). The general attitude favoring the assumption of a single learning and memory system has been retained by most practitioners to this day.

We can only speculate about the reasons for the long-lived popularity of the idea of a single learning and memory system. But it is reasonable to assume that prominent among the factors that have played a role in creating and maintaining the picture of a world with a single learning and memory system have been the following:

(1) The absence of obvious, easily perceived boundaries between different kinds of learning and remembering. It is much easier to

perceive continuities than discontinuities among different manifestations of learning and memory. Like the primitive man who knew a large variety of diseases but had only casual observations to guide him, and who ignored the classification problem - by assigning all sicknesses to a single category, frequently with a single explanation - or at best classified sicknesses by the body part affected, the early students of learning and memory adopted the convenient assumption of a single system, at most distinguishing among different "forms" of learning in terms of such "body parts" as the learning species (e.g., human learning, animal learning) or some characteristic of the task given to learners in experiments (e.g., avoidance learning, memory for prose).

(2) The corresponding use of a single word in the language, either "learning" or "memory", depending upon the fashions of the time, to refer in a general way to manifestations of plasticity of behavior and thought of all sorts. Although as psychologists we frequently make up new terms to designate novel facts or ideas, we have been curiously reluctant to tamper with broad categories such as "learning" and "memory".

(3) The apparent parsimony inherent in the idea of a single system. Concepts of unity, oneness, and wholeness have strong positive emotional appeal to people; they are in the same category with harmony, peace, and serenity (or dharma, heaven, and nirvana). In science, the appeal of all great theories lies in their ability to integrate otherwise apparently unrelated facts and phenomena, and to subsume them under a few general and comprehensive principles. In psychology, too, the search for a general theory of behavior, or of the mind, or at least a general theory of learning, or of memory, have been regarded as more ennobling than the advocacy of multiple behavioral and experiential learning systems. To argue against the unity of learning, or at least its basic continuity, is tantamount to doubting the harmony of nature and the universe.

(4) The ease with which phenomena that might be regarded as supporting the existence of multiple learning and memory systems can be explained, or explained away, in ways that do not necessitate the revision of the one-memory, or one-learning idea. Psychological theorizing is a highly flexible enterprise and permits the theorist a great deal of freedom. We have always been blessed with many, rather than troubled by few, explanations of our phenomena. Typically they are all plausible to some extent, while none is clearly superior to the others. At the level of current theoretical sophistication, it is relatively simple to come up with explanations of phenomena that conform to one's basic pretheoretical convictions, such as convictions about the essential unity of learning and memory systems.

(5) No **convincing** neurophysiological evidence for separate existence of different memory systems. Experimental psychologists, by and large, have not been overly concerned with relations between their theoretical ideas and facts about the nervous system. The fear has been that such concern might lead to physiological reductionism, an idea whose respectability matches that of the idea of multiple learning and memory systems. In addition, whatever relevant evidence has existed was always open to alternative interpretations. Only the grossest of differences in the anatomy, physics, and physiology of vision and audition, and other senses, have created a situation in which everyone is willing to regard them as distinct sensory systems, rather than representing only different modes of operation of the unitary perceptual system. Since no similarly compelling evidence of differences in the neural basis of separate learning and memory systems has as yet been produced, the assumption of a single system has retained its dominance. The current debate about the existence of different visual systems (e.g., Leibowitz & Post, 1982) has so far remained inconclusive partly because of complications in the search for neuroanatomical evidence (e.g., Ungerleider & Mishkin, 1982).

REASONS FOR CHANGE

Whatever the historical roots of the single-system pretheory, and however dominant the idea, there are now signs in the air that the assumption of a single learning and memory system is going to be abandoned. A number of reasons for such a change can be identified.

A major reason for abandoning the one-learning, one-memory idea has to do with the metatheoretical strategy of research. Many observers agree that the progress in learning and memory research has been somewhat uneven: a large volume of empirical findings and experimental facts have been generated while at the same time attempts to construct a general theory of learning and memory have met with little success. Given such a state of affairs, it is natural to wonder about its causes. Once the question is raised, it is equally natural to wonder whether the theoretical difficulties are related, at least partially, to some of the covert pretheoretical assumptions that have provided the underpinnings of the theoretical enterprise. The pretheoretical assumption of a single learning and memory system is conspicuous among such assumptions. It is possible that it is wrong. If so, theory construction may have been frustrated, simply because theorists tried to achieve something that was impossible by the standards of nature.

Consider some of the theoretical battles in the psychology of learning and memory that have been fought inconclusively in the past. Is temporal contiguity of a stimulus and a response sufficient for the development of an association between them? Is reinforcement necessary for learning to occur? What role does feedback play in the acquisition of new knowledge? Is retrieval of stored information a constructive process or is it a matter of activating existing associations? Is context important in the acquisition and utilization of new knowledge? Do memory traces undergo a period of gradual consolidation after their initial formation or are they fully formed in a small fraction of a

second? Are retrieval processes basically similar to encoding processes? Does repetition strengthen memory traces, or does it create new replicas of them? Is there a basic difference between intentional and incidental learning, or learning that does and learning that does not require attention? Is forgetting caused by interference or does it come about because of decay?

The list of these kinds of questions could be extended greatly. They all have in common at least two properties: they can be thought of as basic, and the answer to each has turned out be, "It depends." Empirical evidence shows that it depends on characteristics of particular situations in which relevant observations have been made; theoretical speculation suggests that it depends on the nature of contributions that different learning and memory systems make to the behavior or experience under observation.

Other reasons for revising the assumption of a single learning and memory system have to do with empirical facts. Four classes of such facts can be singled out for brief mention in the present context.

First, a good deal of reliable data now exist that attest to a sharp distinction between impaired and preserved learning functions in brain-damaged patients. Neuropsychological studies have shown that densely amnesic patients, who may be incapable of learning the meaning of a single new word, or of remembering the contents of a simple conversation in which they participated only a few minutes ago, can nevertheless learn new skills and habits, some of them at rates indistinguishable from that shown by normal control subjects. Recent reviews have been provided by Cohen (in press), Parkin (1982), and Squire and Cohen (in press).

Among particularly striking findings are those reported by Cohen and Squire (1980), showing that amnesics can learn to read mirror-image type as readily as normals, and retain the skill without any impairment

for at least three months, despite the fact that they have no conscious recollection whatsoever of the learning experiences. Equally striking is the ability of the well-known patient H. M.(Milner, 1966), as well as other amnesic patients, to learn to solve the Tower of Hanoi puzzle with the same facility that characterizes the learning of normal subjects (Cohen, in press).

These and many other similar dissociations between impaired and preserved learning and memory functions point to the existence of specialized neural mechanisms that underlie or mediate different kinds of learning: damage to certain brain structures and mechanisms that causes severe dysfunction for some kinds of learning and memory has no similar effect on others.

The second class of relevant empirical findings consists of demonstrations of dissociations in learning and memory performance brought about by surgical lesions of brain structures. A particular lesion may result in severe impairment or even complete abolition of learning a particular task, or a component of a task, without similar impairment of the performance on some other task, or another component of the same task (e.g., Gaffan, 1974; Mishkin, Malamut & Bachevalier, in press; Mishkin & Petri, in press; Olton, Becker & Handelmann, 1979; Olton & Papas, 1979). The theoretical and metatheoretical implications of these findings are the same as those of dissociations between preserved and impaired memory functions in amnesic patients: different neural mechanisms are involved in different kinds of learning.

The third category of evidence has to do with dissociations in learning and memory performance brought about by experimental inducement of temporary, reversible changes in brain states. For instance, it has been shown that post-hypnotic amnesia suggestions can lead to serious impairment in, and sometimes total failure of, recall of verbal material learned in an experimental situation, without any comparable effect on the

subjects' ability to produce the same material when performing a different memory task (Kihlstrom, 1980; Williamsen, Johnson & Eriksen, 1965). In a similar vein, acute ingestion of alcohol in moderate doses has been shown to produce an impairment in performance on some memory tasks, such as recall and recognition, without affecting other kinds of positive consequences of learning, such as word-fragment completion (Hashtroudi, Parker, Delisi & Wyatt, in press; Parker, Schoenberg, Schwartz & Tulving, in press). As yet another example is provided by the research of Bennett, Davis and Giannini (1981) in which it was shown that deeply anesthetized patients undergoing surgery acquired, retained, and subsequently acted upon verbal instructions that they heard while in the unconscious state on the operating table, even though they had no conscious awareness of either the fact or the contents of the instructions.

The lesson taught by all these experiments is the same as that inherent in the dissociations in amnesic patients and experimentally lesioned animals: different brain mechanisms underlie performances on different learning and memory tasks.

The fourth category of relevant evidence consists of demonstrations of dissociations between performances on different memory tasks in typical laboratory experiments done with wide-awake, healthy, normal human beings. Kolers (1975), for instance, has shown that such subjects can retain the experimentally acquired skill of reading a transformed script as long as a year after the original learning episode, despite the fact that they show no recollection of the contents of the material they read. Jacoby and Witherspoon (1982) have shown that tachistoscopic identification of words is facilitated (primed) by the previous exposure of the words to the subjects, but that such priming is stochastically independent of subjects' episodic recognition of the words. Similar results were obtained by Tulving, Schacter, and Stark (1982), in an experimental comparison of the effects of experimental learning of words

on subsequent recognition and word-fragment completion. In the latter task, the subject is given a fragment of a word (a word with some letters deleted but indicated, e.g., AS---IN and HO---ON, for "assassin" and "horizon"). Word-fragment completion performance in the Tulving et al. (1982) experiment showed sizable priming effects which were uncorrelated with recognition performance: the priming effect was as large for words that the subjects recognized as having occurred in the study list as it was for words that the subjects thought were "new". Furthermore, the priming effect, unlike recognition performance, was as large a week after study as it was an hour after study.

Another experiment in this genre has recently been reported by Eich (in press). Under conditions of divided attention, subjects shadowed a message that they heard in one ear, while unrelated critical material was presented to the other ear. This unattended critical material consisted of homonymous words. Each was presented in the context of another word that strongly suggested one of the meanings of the homonymous word. A subsequent recognition memory test showed that subjects could not reliably distinguish target homonyms from new control words. However, when the subjects were asked to spell the homonyms, their behavior showed clear evidence of the effect of the unattended material. Like the surgical patients in the Bennett et al. (1981) experiment, who were unaware of what they had heard during surgery but nevertheless showed an effect in their behavior, Eich's subjects demonstrated a striking dissociation between performances on two different memory tasks involving the same original input. An appropriate interpretation of such dissociations, as well as those shown by Kolers (1975), Jacoby and Witherspoon (1982), and Tulving et al. (1982) is that different memory performances are mediated by different memory systems. Under conditions where the operations of one system are impaired, or where one system fails altogether, the other system can operate with a certain degree of success.

MEMORY DICHOTOMIES, TRICHOTOMIES, AND BEYOND

The pretheoretical assumption of a single learning system has not gone unchallenged all the time. Every now and then, suggestions for basic distinctions in learning and memory have been made. For example, the distinction between two kinds of conditioning, classical (Pavlovian) and instrumental (Skinner, 1938), is known to all students of psychology, as is the distinction between short-term and long-term, or primary and secondary, memory (Atkinson & Shiffrin, 1968; Waugh & Norman, 1965). Other suggestions for distinctions, made by philosophers and neuroscientists (e.g., Bergson, 1911; Malcolm, 1963; Nielsen, 1958; for a review, see Herrmann, 1982) have been known under different labels; they are now usually referred to as episodic and semantic memory (Tulving, 1972, 1983).

Until recently, these distinctions did not have much impact on the overall strategy of theory construction. Most students of learning and memory have retained to this day the orienting attitude that search for a unifying theory of learning and memory is respectable, and the assumption of basically different learning and memory systems is not. As a result, suggested distinctions have been accommodated within the general pretheory that holds that all phenomena of learning and memory, at some level of abstraction, reflect the operations of a single system. Since the proponents of distinctions have always been in the minority and since they have usually couched their ideas in rather cautious terms - because of the inherent conservatism of science, because of lack of suitable evidence to strongly support their convictions, or for some other reason - the view of the majority on the issue of unity and continuity of learning and memory has remained unchanged for a long time.

A shift in the basic attitude seems to be in progress, however. The exercise in the prognosis presented in this essay is not only possible

but quite easy because of what has happened in recent years: the particular prediction made herein constitutes a relatively straightforward projection of current developments into the future. A relatively large number of students of learning and memory - large by historical standards - have begun to argue seriously and strongly in support of fundamentally different **kinds** or **forms** of learning and memory, while some have already gone as far as to talk publicly about the existence of different memory **systems** (e.g., Cohen, in press; Mishkin et al., in press; Schacter & Moscovitch, in press; Schacter & Tulving, 1982; Tulving, 1983). The drive is spearheaded jointly by experimental psychologists and neuropsychologists.

Most proposed distinctions are what one might naturally expect as a first step away from the one-learning or one-memory view, namely dichotomies of various kinds. Thus, we have distinctions between episodic and semantic memory (e.g., Herrmann, 1982; Kinsbourne & Wood, 1975, 1982; Parkin, 1982; Schacter & Tulving, 1982; Tulving, 1983; Wood, Ebert & Kinsbourne, 1982), between cognitive mediational and semantic memory (Warrington & Weiskrantz, 1982; Weiskrantz, 1982), automatic retrieval and recollection (Baddeley, 1982), knowing how and knowing that (Cohen & Squire, 1980; Squire & Cohen, in press), procedural and declarative knowledge (Cohen, in press), working and reference memory (e.g., Honig, 1978; Olton, Becker & Handelmann, 1979; Olton & Papas, 1979), and between memories and habits (Mishkin, Malamud & Bachevalier, in press; Mishkin & Petri, in press), among others.

The proposed dichotomies by no means parallel one another; the extant list as a whole includes several different branches of the future taxonomic tree of learning and memory systems. The fact that a single theorist, or a particular team, typically argues for two rather than more forms of learning or memory simply shows that it is difficult to find three things if one is looking for two, as it is difficult to find

two if one believes in advance of the search that there is only one. This also means that if there are in nature n learning and memory systems, we are most likely to discover them one by one, adding to our list one system at a time.

If we hesitate to accept suggestions such as those of Tolman (1949) for six types of learning, and Miller and Johnson-Laird (1976) for five kinds of memory, because of lack of systematically elaborated supporting evidence, we are left with trichotomies of learning and memory as the most comprehensive typologies at the present time. For instance, Locke (1971) has compared in some detail three kinds of memory - practical, factual, and personal - which correspond to procedural, semantic, and episodic memory that have been analyzed thoroughly by psychologists and neuropsychologists (e.g., Cohen & Squire, 1980; Schacter & Tulving, 1982).

The relations among the three kinds of learning and memory constitute one of the many open problems. One popular idea holds that a fundamental distinction exists between procedural and declarative knowledge, and corresponding forms of memory (e.g., Bruner, 1969; Cohen, in press; Cohen & Squire, 1980; Kolers, 1975; Ryle, 1949). As an extension of this scheme, it has been suggested that episodic and semantic memories represent subsystems of the propositional (declarative) memory system (Tulving, 1983). The memory system that mediates procedural knowledge does not permit conscious access to the contents of the stored knowledge and does not permit people to verbalize the knowledge; procedural knowledge can be expressed only through action. The contents of episodic and semantic memories, on the other hand, are similar in that both handle knowledge that is accessible to consciousness and that can be expressed symbolically, although they differ in other ways (Tulving, 1983).

An obvious alternative hypothesis to the one that draws a major distinction between procedural and propositional learning systems, with other systems subsumed by one or both of these major systems, would hold that no separate procedural memory system exists, and that each existing system operates according to its own specialized procedures.

The number of learning and memory systems that will eventually be discovered is almost certainly going to be larger than three. Primitive learning systems possessed by lower organisms have not been supplanted by more sophisticated systems in higher organisms, even if so far they have escaped psychologists' attention. Other systems may mediate little-studied phenomena of learning and memory, such as direct priming effects (e.g., Ellis & Collins, 1983; Jacoby & Dallas, 1981; Jacoby & Witherspoon, 1982; Morton, 1979; Tulving, Schacter & Stark, 1982), that do not seem to fit well into the categories of procedural, semantic, and episodic memory (Tulving, 1983), and may therefore require classification outside this trichotomy. And it is more than likely that new, as yet completely unknown, forms of learning and memory will be discovered in the future.

DEFINING FEATURES OF LEARNING AND MEMORY SYSTEMS

The problem of exactly what constitutes a learning and memory system, together with the attendant problems of how to identify them and to distinguish among them, will be solved in the future. The search for the solutions, however, has to begin somewhere. A convenient starting point is a listing of some of the defining features of systems that would be acceptable to most theorists who have abandoned the single-system view of learning and memory. One such list follows.

(1) Different systems serve separate, largely nonoverlapping behavioral and cognitive functions. They mediate the

acquisition and retention of different kinds of information and knowledge that are used by the organism for different purposes, under different conditions.

(2) Different systems operate according to different laws and principles. Although all learning and memory systems share some features - they all enable the organism to make use of information acquired on an earlier occasion - all the processes of different systems need not be the same: what is true of one system is not **necessarily** true of another.

(3) The behavioral and cognitive functions of different systems are represented in the brain by different neural structures, different neural mechanisms, or both. Each such structure or mechanism is specialized for a particular set of behavioral or experiential functions. It is sometimes possible for one neural learning and memory system to substitute for another, albeit at a less efficacious level; it is also possible for the activity of one of the neural systems to modulate that of another.

(4) Different systems have developed at different stages in the phylogeny of the species, representing the responses of the species to changes in environmental demands for survival. Analogous changes may occur in the ontogeny of individual members of the species in some cases: depending upon the time course of the maturation of the brain, different kinds of learning and memory functions become possible at different ages of the developing individual.

(5) Different systems differ from one another with respect to the format of representation of acquired information. In some, the representation may be "causal", in others it may be "informational", in the sense in which the terms have been used by Dretske (1982). The after-effects of a behavioral event registered in a more primitive system may

carry minimal information about the past event, although sufficient information to determine or modify future behavior or experience. On the other hand, representations (engrams, memory traces) laid down in a more advanced system may preserve a good deal of detailed information about the past event.

(6) In the course of an organism's interaction with its environment, several systems may participate in the storing of information, use of information, or both, in a particular situation. The cooperation among the systems may be so effective and smooth that casual observation of behavior creates the impression of a single system in action. A primary challenge facing students of learning and memory lies in the invention of techniques that allow the analysis of the apparent whole into its natural constituent parts.

Verification of the existence, and identification of the properties, of multiple learning and memory systems will rapidly become a major focus of research efforts of neurophysiologists, neuropsychologists, experimental psychologists, as well as workers in other disciplines. The eventual successful achievement of this primary objective will constitute one of the great accomplishments of the future multidisciplinary science of learning and memory. When this happens, we as scientists will have liberated ourselves from the tyranny of everyday language and created a new one that truly mirrors nature.

ACKNOWLEDGEMENT

The writing of this paper has been supported by the Natural Sciences and Engineering Research Council of Canada, Grant No. A8632, and by a Special Research Program Grant from the Connaught Fund, University of Toronto.

REFERENCES

1 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.** Vol. 2. New York: Academic Press, 1968.

2 Baddeley, A. D. Amnesia: a minimal model and interpretation. In L. S. Cermak (Ed.), **Human memory and amnesia.** Hillsdale, N. J.: Erlbaum, 1982.

3 Bennett, H. L., Davis, H. S. & Giannini, J. A. Posthypnotic suggestions during general anesthesia and subsequent dissociated behavior. Paper presented at the Meeting of the Society for Clinical and Experimental Hypnosis, Portland, 1981.

4 Bergson, H. **Matter and memory.** London: Allen & Unwin, 1911.

5 Bruner, J. S. Modalities of memory. In G. A. Talland & N. C. Waugh (Eds.), **The pathology of memory.** New York: Academic Press, 1969.

6 Cohen, N. J. Preserved learning capacity in amnesia: Evidence for multiple memory systems. In N. Butters & L. R. Squire (Eds.), **The neuropsychology of memory.** New York: Guilford Press, in press.

7 Cohen, N. J. & Squire, L. R. Preserved learning and retention of pattern analyzing skill in amnesia: Dissociation of knowing how and knowing that. **Science,** 1980, 210, 207-209.

8 Dretske, F. The informational character of representations. **The behavioral and brain sciences,** 1982, 5, 376-377.

9 Eich, E. Memory for unattended events: Remembering with and without awareness. **Memory & Cognition,** in press.

10 Ellis, A. W. & Collins, A. F. Repetition priming of word fragment completion is modality-specific and independent of conscious episodic memory: a replication and extension of Tulving, Schacter and Stark (1982). University of Lancaster, unpublished manuscript, 1983.

11 Gaffan, D. Recognition impaired and association intact in the memory of monkeys after transection of the fornix. **Journal of comparative and physiological psychology,** 1974, 86, 1100-1109.

12 Hall, T. S. **History of general physiology,** vol. I & II. Cambridge: The University Press, 1969.

13 Hashtroudi, S., Parker, E. S., Delisi, L. E. & Wyatt, R. J. Intact retention in acute alcohol amnesia. **Journal of experimental psychology: Learning, memory, and cognition,** in press.

14 Herrmann, D. J. The semantic-episodic distinction and the history of long-term memory typologies. **Bulletin of the psychonomic society,** 1982, 20, 207-210.

15 Holton, G. & Brush, S. G. **Introduction to the concepts and theories in physical science,** 2nd Ed. Reading, Mass.: Addison Wesley, 1973.

16 Honig, W. K. Studies of working memory in the pigeon. In S. H. Hulse, H. Fowler & W. K. Honig (Eds.), **Cognitive processes in animal behavior.** Hillsdale, N. J.: Erlbaum, 1978.

17 Hunter, W. S. Learning: IV. Experimental studies of learning. In C. Murchison, **A handbook of experimental psychology.** Worcester: Clark University Press, 1934.

18 Jacoby, L. L. & Dallas, M. On the relationship between autobiographical memory and perceptual learning. **Journal of experimental psychology: General,** 1981, 110, 306-340.

19 Jacoby, L. L. & Witherspoon, D. Remembering without awareness. **Canadian journal of psychology,** 1982, 36, 300-324.

20 Kihlstrom, J. F. Posthypnotic amnesia for recently learned material: Interactions with "episodic" and "semantic" memory. **Cognitive psychology,** 1980, 12, 227-251.

21 Kinsbourne, M. & Wood, F. Short-term memory processes and the amnesic syndrome. In D. Deutsch & J. A. Deutsch (Eds.), **Short-term memory.** New York: Academic Press, 1975.

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

23 Kolers, P. A. Specificity of operations in sentence recognition. **Cognitive psychology,** 1975, 1, 289-306.

24 Leibowitz, H. W. & Post, R. B. The two modes of processing concept and some implications. In J. Beck (Ed.), **Organization and representation in perception.** Hillsdale, N. J.: Erlbaum, 1982.

25 Locke, D. **Memory.** Garden City, N. Y.: Doubleday, 1971.

26 Malcolm, N. **Knowledge and certainty: Essays and lectures.** Englewood Cliffs, N. J.: Prentice-Hall, 1963.

27 McGeoch, J. A. & Irion, A. L. **The psychology of human learning.** New York: Longmans, Green, 1952.

28 Miller, G. A. & Johnson-Laird, P. N. **Language and perception.** Cambridge, Mass.: Belknap, 1976.

29 Milner, B. Amnesia following operation on the temporal lobes. In C. W. M. Whitty & O. Zangwill (Eds.), **Amnesia.** London: Butterworths, 1966.

30 Mishkin, M., Malamut, B. & Bachevalier, J. Memories and habits: Two neural systems. In J. L. McGaugh, G. Lynch. & N. M. Weinberger (Eds.), **The neurobiology of learning and memory.** New York: Guilford Press, in press.

31 Mishkin, M. & Petri, H. L. Memories and habits: Some implications for the analysis of learning and retention. In N. Butters & L. R. Squire (Eds.), **Neuropsychology of memory.** New York: Guilford Press, in press.

32 Morton, J. Facilitation in word recognition: Experiments causing change in the logogen model. In P. A. Kolers, M. E. Wrolstad & H. Bouma (Eds.), **Processing of visible language,** Vol. I. New York: Plenum Press, 1979.

33 Nielsen, J. M. **Memory and amnesia.** Los Angeles: San Lucas Press, 1958.

34 Olton, D. S., Becker, J. T. & Handelmann, G. E. Hippocampus, space, and memory. **The behavioral and brain sciences,** 1979, 2, 313-365.

35 Olton, D. W. & Papas, B. C. Spatial memory and hippocampal function. **Neuropsychologia,** 1979, 17, 669-682.

36 Parker, E. S., Schoenberg, R., Schwartz, B. L. & Tulving, E. Memories on the rising and falling blood alcohol curve. **Bulletin of the psychonomic society,** in press.

37 Parkin, A. Residual learning capability in organic amnesia. **Cortex,** 1982, 18, 417-440.

38 Ryle, G. **The concept of mind.** San Francisco: Hutchinson, 1949.

39 Schacter, D. L. & Moscovitch, M. Infants, amnesics, and dissociable memory systems. In M. Moscovitch (Ed.), **Infant memory.** New York: Plenum Press, in press.

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

41 Skinner, B. F. **The behavior of organisms.** New York: Appleton-Century, 1938.

42 Squire, L. R. & Cohen, N. J. Human memory and amnesia. In J. L. McGaugh, G. Lynch & N. M. Weinberger (Eds.), **The neurobiology of learning and memory.** New York: Guilford Press, in press.

43 Tolman, E. C. There is more than one kind of learning. **Psychological review,** 1949, 56, 144-155.

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

45 Tulving, E. **Elements of episodic memory.** Oxford: Clarendon Press, 1983.

46 Tulving, E., Schacter, D. L. & Stark, H. A. Priming effects in word-fragment completion are independent of recognition memory. **Journal of experimental psychology: Learning, memory, and cognition,** 1982, 8, 336-342.

47 Ungerleider, L. G. & Mishkin, M. Two cortical visual systems. In D. J. Ingle, M. A. Goodale & R. J. W. Mansfield (Eds.), **Analysis of visual behavior.** Cambridge, Mass.: MIT Press, 1982.

48 Warrington, E. K. & Weiskrantz, L. Amnesia: A disconnection syndrome? **Neuropsychologia,** 1982, 20, 233-248.

49 Weiskrantz, L. Comparative aspects of studies of amnesia. In D. E. Broadbent & L. Weiskrantz (Eds.), **Philosophical transactions of the Royal Society of London.** London: The Royal Society, 1982, 298.

50 Waugh, N. C. & Norman, D. A. Primary memory. **Psychological review,** 1965, 72, 89-104.

51 Williamsen, J. A., Johnson, H. J. & Eriksen, C. W. Some characteristics of posthypnotic amnesia. **Journal of abnormal psychology,** 1965, 70, 123-131.

52 Wood, F., Ebert, V. & Kinsbourne, M. The episodic-semantic memory distinction and amnesia: Clinical and experimental observations. In L. S. Cermak (Ed.), **Human memory and amnesia.** Hillsdale, N. J. : Erlbaum, 1982.