BOOK REVIEWS

Taking stock

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Memory and Brain

By Larry R. Squire. 1987, Oxford University Press.
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It will probably come as no surprise to readers of this journal that the neurobiological study of memory has undergone rapid and exciting growth during the past decade. Research at the cellular level has yielded important new insights into synaptic contributions to memory, studies of simple organisms such as aplysia have provided remarkably complete descriptions of memory mechanisms in restricted domains, more complex neural circuits involved in learning and memory have been delineated in impressive detail, and neuropsychological studies of amnesic patients have stimulated a variety of ideas concerning multiple memory systems. With all of these and other developments proceeding rapidly and in parallel, an integrative review and assessment of them would be timely and useful. In *Memory and Brain*, Larry Squire takes on this task and accomplishes it with a considerable degree of success.

The general plan of the book is to begin at the synaptic-cellular level and work progressively "upward" to system-level analyses. The coverage of synaptic bases of memory is quite brief, but summarizes effectively alternative hypotheses concerning mechanisms of synaptic efficacy. Rather more attention is paid to developmental studies that have elucidated principles of neural change that may be relevant to understanding memory phenomena, particularly the principle of competition, whereby the elimination of groups of axons in a particular brain region leads to an increase in the influence of remaining axons. Squire uses this and related ideas at several points in the book to support the notion that forgetting may involve an actual loss of connectivity or information, as opposed to loss of access to information that is available in storage. Squire expresses clear disdain for the most radical formulation of the latter idea, namely, that all learning is permanently stored and that all forgetting represents loss of access. Because this idea is by its very nature virtually impossible to refute unequivocally

in behavioral studies—even if forgetting is observed across a range of retrieval conditions, it can always be argued that some other, more appropriate retrieval condition would produce evidence of memory—Squire contends that it will have to be settled ultimately on neurobiological grounds. Because neurobiological evidence indicates that actual loss of information from storage *can* occur, the argument runs, it is reasonable to assume that it *does* occur in specific instances of forgetting. This line of reasoning is cogent and undermines the extreme view that all stored experiences are permanently retained. However, Squire pays little attention to the fact that numerous behavioral studies have shown clearly that loss of access to stored information does contribute to forgetting. One should not confuse the extreme and probably untenable view discussed above with the valid idea that failures to gain access to stored information are important sources of forgetting; 20 years' worth of research in cognitive psychology and neuroscience supports this notion. Although Squire does not argue that access failures play no role in forgetting, in my view he does not place sufficient emphasis on the importance of understanding the *relative* contributions of storage and access failures and delineating the conditions under which they occur. It would be unfortunate if this important issue were reduced to an overly simplistic either/or (i.e., storage failure or access failure) status.

Two chapters notable for their historical sensitivity concern the issue of localized versus distributed memory storage and the Penfield electrical stimulation studies, respectively. The former chapter contains an extremely clear depiction of the central issues and the sensible reconciliation of apparently conflicting positions. As Squire argues, both localization and distributed accounts are true in certain senses: Localization is observed, insofar as different brain regions appear to be associated with storage of different kinds of information, but distributed representation is observed within specific regions. The chapter on the Penfield studies reminds us that the dramatic results obtained with temporal lobe stimulation—apparent reevocation of vivid, detailed memories—occurred in only a small minority of patients and in most instances did not involve any veridical "reliving" of a specific experience. Rather, the elicited mental phenomena were often dream-

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like sequences or odd mixtures of fragments from a patient's past. Squire also marshals evidence from more recent studies that cast doubt on the idea that electrical stimulation activates specific neurons or small groups of neurons that represent particular memories.

The localization theme is pursued more thoroughly in two highly effective chapters on simple and complex learning that provide the reader with useful summaries of various pertinent research programs. Squire's description of the experiments carried out by Thompson and his colleagues concerning conditioning of the nictitating membrane response is particularly detailed and informative, and his portrayal of Mishkin's work on area TE and visual memory also comes across quite clearly. Squire convincingly integrates the material in these chapters to support the general proposition that specific cortical processing systems are likely sites of memory storage. These excellent chapters are followed by a rather less satisfying chapter that attempts to develop the theme that memory is determined by information processing. Squire advances several lines of evidence from neuroscience and cognitive psychology to support this thesis, but the material is somewhat disjointed and he does not offer more than a capsule conceptual analysis of the problem.

The issue of multiple memory systems assumes center stage in the next chapters. The question of short-term versus long-term memory is dealt with first. In view of the vast amount of data that are pertinent to this theme, I was somewhat disappointed with the highly selective and rather brief treatment accorded it; Squire presents only a few familiar studies of the subject. On the other hand, he does expend some effort in attempting to reconcile different and seemingly conflicting uses of the term *short-term memory*, and argues persuasively that exactly what is meant by this term depends on the level of analysis at which the problem is addressed.

The chapter on divisions of long-term memory deals with research in which Squire himself has played a major role with his work on preserved learning in amnesia and his advocacy of a distinction between procedural and declarative memory systems. The chapter describes some of this work in a comprehensible manner, and presents Squire's current conception of the procedural/declarative distinction. It also contains some puzzling statements. Consider, for example, Squire's account of the phenomenon of direct or repetition priming. *Priming* refers to facilitation of test performance by prior exposure to an item (e.g., a familiar word) during a specific study episode. Tests that tap priming do not require explicit or intentional remembering of any particular prior experience; subjects simply perform a task, such as completing a three-letter stem with the first word that comes to mind. Studies reported by Warrington and Weiskrantz in the 1970s, and later followed up by various researchers including Squire's own group, have demonstrated that amnesic patients show normal or intact priming effects across several different experimental conditions. Experiments with normal subjects have shown that priming can be dissociated from per-

formance on standard memory tests by a variety of experimental manipulations. As part of a generally accurate description of various priming effects, Squire asserts that "priming is a short-lived phenomenon" (p. 161). This statement will very likely startle many who are familiar with the literature on direct priming, inasmuch as a key characteristic of it, which has assumed a prominent role in theoretical debates, is the enduring persistence of the phenomenon, lasting across days, weeks, and months. Squire's statement appears to derive largely from his own work, which has found that amnesic patients show short-lived priming effects in certain paradigms. He ascribes observations of long-lasting priming in normal subjects to augmentation of performance by "ordinary memory strategies" (p. 156), strategies that are not available to amnesic patients. Unfortunately, he cites no evidence to support this observation and ignores data that argue against it—namely, that priming and remembering can be dissociated experimentally in normal subjects at long delays as well as at short delays. Although there may be important differences between short-lasting and long-lasting priming, it is misleading to state that priming is a short-lived phenomenon simply because it decays rapidly in some studies of amnesic patients (in fact, we have recently produced evidence of long-lasting priming in amnesic patients).

I also found Squire's conception of the procedural/declarative distinction a bit unclear. This distinction was originally advanced in cognitive psychology and artificial intelligence to capture the difference between "knowing how" and "knowing that." Squire goes beyond this and applies the term *procedural* to a whole host of phenomena (e.g., priming, skill learning, classical conditioning) that differ in many respects, but have in common the fact that they can be expressed in the absence of conscious remembering and can be accomplished by amnesic patients. Declarative memory refers to memory for facts and events that are accessible to awareness. Since Squire applies the term *procedural* to diverse learning abilities, he would appear to be using it as a general descriptive term. Elsewhere, however, he states that "the nervous system recognizes a distinction between two kinds of memory processes or systems [declarative and procedural]" (p. 160). This sort of statement entails a *process* distinction rather than a *descriptive* distinction, and implies that biologically coherent declarative and procedural systems exist. It is when this sort of conception is contrasted with the descriptive notion that procedural memory is a "collection of different abilities" (p. 164) that confusion can arise. If *procedural* does not refer to a single system, it would make more sense to apply precise terms to each of the individual abilities that are grouped together under this general heading, and thus avoid the apparently misleading implication that there is a procedural system that works according to one set of rules and a declarative system that operates according to another. As it stands, this reader is still unclear as to exactly what criteria Squire uses for distinguishing between

declarative and procedural memory independently of a particular experimental outcome (i.e., whether or not amnesic patients show intact performance on a particular task).

The final two chapters of the book examine closely the memory functions of the medial temporal lobe and the frontal lobe, respectively. These chapters succeed admirably in providing the reader with a cohesive picture of current knowledge and thinking concerning the contrasting roles of these two structures in various kinds of memory tasks. Particularly noteworthy is the author's thoughtful integration of data from human and animal paradigms.

On balance, *Memory and Brain* is a clear and scholarly summary of some of the major developments in the re-

cent neurobiology of memory that also pays homage to earlier pioneers in the field. One of the major virtues of the book is its breadth of informative coverage. More depth of analysis would have been welcome in some places, but one can hardly complain about this in any book that successfully attempts to cover as much ground as Squire's monograph does. I would particularly recommend the book to those who seek a basic introduction to the field as a whole or to a specific research area with which they are unfamiliar. Although one can take issue with some of the author's views, my overriding impression is that Squire has accomplished most of what he set out to do in *Memory and Brain*, and thereby has made a significant contribution to the field.