Book Reviews

An Alternative View of Memory Storage

Mechanisms of Memory. E. Roy John. Academic Press, New York, 1967. xxi + 468 pp., illus. $14.

The dominant view of memory mechanisms has been that memory storage consists of the formation of specific pathways connecting receptors and effectors. Most current theories of memory accept this general view and assume that information storage and retrieval involve alterations of specific cells in specific neural circuits.

In *Mechanisms of Memory*, E. Roy John has attempted to provide an alternative view of memory storage, one which is consistent with older as well as recent experimental findings concerning the biological bases of memory. John begins by reminding us that Lashley's objections to the specific-connectionistic view of memory are still valid: that is, that such a narrowly deterministic explanation is inconsistent with the evidence of plasticity in brain and behavior. Recognition of this problem states, but does not solve, the problem of memory. If the connectionistic assumption is rejected, what alternative is there? How is information stored in neural tissue, if not in connections between specific cells and specific pathways?

John proposes that memory is based on the patterned activity of aggregates of cells. According to John, an experience caused by stimulation in a given environment alters the baseline activity of populations or networks of cells. The temporal sequence of states of the network he terms the *mode* of activity. John suggests that "increase in the probability of coherent activity in that mode constitutes the stored memory" (p. 65). Information storage consists of increasing the likelihood that a particular mode of coherent oscillation will be produced in the network of cells.

John suggests that the storage of the memory of an event is accomplished in the following way: The event causes an alteration of the neural network, which is sustained for some period of time. This alteration induces protein synthesis. He suggests that the protein maintains the synthetic cycle and modifies the responsiveness of the cell's membrane to particular sequences of stimulation. Thus, chemical changes occurring during memory consolidation increase the probability of modes of oscillation originally caused by the stimulus event.

According to John, memory retrieval requires a mechanism that assesses the congruence between the oscillation of cells (termed *stable cells)* which display invariant responses to afferent stimulation and that of cells (termed *plastic cells*) whose coherence has been influenced by prior experience. Initiation of oscillations in the plastic cells constitutes retrieval, and coincidence between the two modes indicates that the event is familiar.

Much of the evidence reviewed by John—particularly that from his own laboratory—is consistent with the general theory proposed. He gives considerable emphasis to evidence suggesting that patterns of electrophysiological discharge can comprise information for the brain. For example, he has shown that animals can learn to respond differentially to electrical pulses which are equated for energy but which differ in pattern. Further, he has shown that when an animal is trained to respond to intermittent sensory stimuli, many regions of the brain exhibit electrical rhythms related to the frequency of stimulus. The rhythms are seen between training trials, but not when the animals are in their home cages.

In a very exciting series of studies John and his co-workers have demonstrated that, with training, there is an increase in the similarity of evoked electrical responses in various brain structures. Further, in animals trained to discriminate between different frequencies of peripheral stimulation, the evoked responses obtained during subsequent generalization tests depend upon the behavioral responses performed by the animals. These are but examples of numerous experimental results providing evidence that the information content of the activity of a neural aggregate is reflected in the temporal pattern of the activity of the ensemble. This evidence is at least consistent with the theory he proposes.

John does not specify how the retrieval of information results in initiation of action, that is, in excitation of effectors controlling performance relevant to the retrieved information. His own findings have shown, for example, that following the conditioning of electrophysiological rhythms the activation of the rhythms is neither a necessary nor a sufficient condition for the occurrence of the appropriate behavioral response. Clearly, there must be some mechanism to couple brain activity with performance.

A serious problem facing the theory is that of specifying the means by which memories are distinguished from information provided by afferent stimulation. The following quotation indicates the nature of the problem: "A salient feature of these hypotheses . . . was the expectation that the electrical characteristics of readout of stored information memory would literally reproduce the wave shape displayed by the responsive neural population during the actual experience." If repeated experience increases coherence in the mode of activity, it is difficult to see how any single experience could match the mode of experienced cells. Further, assuming that this could occur, it is not clear how the system is to distinguish perception from memory.

Overall, the theory proposed by John is a compelling challenge to deterministic theories of memory. Its major virtues are that it is based on recognition of the inadequacy of such theories, and that it is generally supported by a variety of experimental findings. *Mechanisms of Memory* is by far the best available review of current fact and theory concerning memory mechanisms. The studies cited by John cover a wide range of experimental areas as well as sources, including a large number of as yet unpublished papers from numerous laboratories. Those interested in human learning and memory will be disappointed to find that no attempt is made to consider the extensive behavioral literature concerning learning and forgetting. Although the review is extensive, it is selective. For example, the immense

literature concerning the effects of brain lesion on learning and memory is virtually ignored.

Mechanisms of Memory should be read, and no doubt will be read, by all who are working in this field, and will serve other biologists and psychologists as a highly stimulating introduction to the subject. The level of difficulty varies somewhat from chapter to chapter, but that is not a glaring weakness. The book should be extremely useful in senior and graduate courses in learning and memory. It will undoubtedly take its place alongside the writings of D. O. Hebb and Karl Lashley as one of the most influential treatises dealing with the problems of memory.

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ABM: In the Public Domain

Debate the Antiballistic Missile. EUGENE RABINOWITCH and RUTH ADAMS, Eds. Published for the *Bulletin of the Atomic Scientists* by the Educational Foundation for Nuclear Science, Chicago, 1967. vi + 172 pp., illus. Cloth, $5; paper, $1.50.

This book, for the most part a collection of papers reprinted from the May and June 1967 issues of the *Bulletin of the Atomic Scientists,* deals with a vital issue that should still be a subject for debate, despite Secretary McNamara's announcement, on 18 September 1967, of the decision to deploy a "thin ABM for protection against a Chinese attack." In addition to the arguments against an ABM deployment presented then by McNamara, the papers in *Debate the Antiballistic Missile* convincingly state most of the others. The few arguments for deployment are also contained in this collection. There is little that is new for those who have followed the subject closely, but even for the experts the book serves the useful purpose of assembling these thoughtful papers in convenient form. Its chief value is that it puts forth the issue as a subject to be debated in the public arena. The foreword makes this point explicitly:

> The technological details of the system and its effectiveness are indeed hidden by security restrictions, but the political and psychological aspects, equally if not more importantly, are in the public domain. *It is the responsibility of citizens to see that the subject is openly and intensively debated* [italics added].

The book presents technical features of the problem in a general way in McNamara's Posture Statement of 23 January 1967 and in an article excerpted from "Nike, the Winged Goddess: Can She Defend Us?," a publication of the Committee for Nuclear Information, St. Louis. The article raises the very serious question whether the Nike-X system can be effective, requiring as it does extraordinary reliability and coordination on the part of many intermeshing components of the system—a point also made in the paper by Oran R. Young.

Dealing with the economics of ABM, McNamara says that an ABM system intended for use against Soviet ICBM's would cost $40 billion over a ten-year period. Substantial updating costs would also be a certainty. Furthermore, additional expenditures would be required for defense against manned bombers, for a fallout shelter program, and for warfare against missile-launching submarines. Wiesner points out that "the operating and maintenance costs of the new system would add several billion dollars a year to the defense budget." These authors and many of the others note that it is much easier for the offense to keep ahead of the defense on both technical and economic grounds.

The only authors supporting an ABM deployment are Freeman J. Dyson and D. G. Brennan. Dyson's support for Nike-X comes in an addendum to an article that originally appeared in the June 1964 issue of the *Bulletin.* In the original article, Dyson acknowledges that there is no defense that can offer any real security against nuclear weapons. "The most important factor for the layman to understand about the technology of BMD [ballistic missile defense]," he says, "is that the race between offensive and defensive systems is a never-ending one" and "It is generally agreed among experts that a limited or token deployment of BMD in the U.S. would be politically impossible." He recognizes "the intense political pressure that exists in both countries to duplicate whatever the other side does," concluding by saying, "The American people must become accustomed to the idea that they may be better off without an ABM system, even if the Soviet people believe they are better off with one." In the addendum, Dyson indicates his preference for Nike-X *rather than* a massive escalation of offensive forces. It is not clear whether he would support Nike-X if that decision had no effect on the question of a drastic increase in offensive forces. The same choice is put somewhat differently by Laurence W. Martin, in suggesting that, on political grounds, West Europeans would be less critical of a restrained U.S. investment in ABM than of a substantial increase in strike forces.

Brennan's arguments are based on the belief that "there are important possibilities in which BMD could play a constructive role, possibilities that support the traditional arms control objective of mitigating the consequences of war if it occurs, without conflicting with the objectives of reducing the likelihood of war and reducing the burden of the arms race." Brennan is interested in the "mix" of strategic forces, as between offense and defense, rather than in the absolute scale of the forces. Using a cost exchange ratio of unity (cost of the offsetting offensive forces equals cost of the defenses that are offset), he argues for a greater proportion of investment in "damage-limitation." But from the tables in McNamara's 1967 Posture Statement, which Brennan cites, it may be seen that the assumed cost exchange ratio becomes unity only when the number of estimated U.S. fatalities is close to the number to be expected if we have no defense. McNamara puts the latter figure at 100 million. By spending as much on defense as the other side would have to spend to offset it, we might hold the level of fatalities at 90 million. As one tries to limit the fatalities to less than this number, the cost advantage shifts to the offense. It is hard to believe that the choice can realistically remain an "either-or"; an initial choice to add to one component of the mix will almost certainly alter the absolute scale of the forces. If, as most of the authors and other experts feel, an intensified offense-defense arms race would ensue from any U.S. antiballistic missile deployment, all the arms control objectives listed by Brennan would be in danger. An intensified arms race would yield less security, the possibility of increased destruction, greater tension, and therefore a greater likelihood of war, and obviously an increased burden on the nations involved.

Martin explores European perceptions of the issue. He feels that many Europeans find ABM destabilizing, that they see it as reinvigorating the arms race, increasing the tension between the Soviet Union and the United States, and making war more likely. Martin himself seems to think that the fears of a runaway arms race may be excessive. He raises a question about the dynamics of the arms race: whether it is driven