

McGaugh J L. Time-dependent processes in memory storage.

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This paper summarized the then recent evidence that processes underlying memory storage are time-dependent. It presented new evidence supporting the view that electrical stimulation of the brain produces retrograde amnesia, as well as evidence that memory is enhanced by posttraining administration of stimulant drugs. [The *Science Citation Index*® (SCI)® and the *Social Sciences Citation Index*® (SSCI)® indicate that this paper has been cited in over 490 publications since 1966.]

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"I wrote this paper shortly after I arrived in the department of psychobiology at the newly (or almost newly) established Irvine campus of the University of California (UC). The work of my own that was included in the paper began a dozen years earlier when I was a graduate student at UC, Berkeley. The research was stimulated by findings, published in the 1940s and 1950s, indicating that electroconvulsive shock (ECS) impairs recently acquired memories.^{1,2} These findings suggested that ECS interfered with time-dependent processes underlying memory consolidation. This interpretation was (and to some still is) controversial. The findings of my own studies of the effects of ECS on memory in rats and mice strongly supported this hypothesis. In addition, I had found, in a series of studies,³ that memory could be enhanced by low doses of central nervous system stimulants if the drugs were administered shortly after training. The evidence suggested that the drugs improved memory

through influences on memory consolidation processes. Much of the earlier work on experimentally induced retrograde amnesia had been reviewed within a few years prior to the time that I wrote this paper.⁴ There were, however, many new findings concerning ECS effects on memory and the studies of drug enhancement of memory had not yet been reviewed in the context of controversial issues in consolidation theory.³ Thus, when I received an invitation to contribute a paper to *Science*, I eagerly accepted.

"The major aim of this paper was to consider recent findings of my own (as well as other) studies concerning the basis of the memory-impairing effects of ECS and to summarize the work from my laboratory concerning drug enhancement of memory. The paper also examined the trade-offs (or interactions) between time and repetition in influence on the strength of memory. This attempt was, alas, largely ignored. Finally, the paper addressed the question of whether more than one memory system (e.g., short-term and long-term memory) is required to account for the findings of these experimental studies of memory.

"The paper was intended simply as an 'update.' Thus, it seems clear why it was frequently cited shortly after it was published. However, since it was neither a pure experimental paper nor a comprehensive review, it is less clear to me why it has continued to be frequently cited. Some of the following possibilities seem to be reasonable explanations. First, the paper appeared at a critical time in the history of memory consolidation research. Some attempt to address the controversial issues was needed. Second, it appeared in a prominent and readily accessible journal. Third, this area of research has remained active and has continued to spawn controversy.^{5,6} It seems that the paper has continued to provide a convenient citation for all sides of all issues."

1. Duncan C P. The retroactive effect of electroshock on learning. *J. Comp. Physiol. Psych.* 42:32-42, 1949. (Cited 130 times since 1955.)
2. Gerard R W. Physiology and psychology. *Amer. J. Psych.* 106:161-73, 1949.
3. McGaugh J L & Petrovich L F. Effects of drugs on learning and memory. *Int. Rev. Neurobiol.* 8:139-96, 1966. (Cited 140 times.)
4. Glickman S E. Perseverative neural processes and consolidation of the memory trace. *Psychol. Bull.* 58:218-33, 1961. (Cited 90 times.)
5. McGaugh J L & Herz M J. *Memory consolidation*. San Francisco: Albion, 1972. 204 p.
6. McGaugh J L. Hormonal influences on memory. *Annu. Rev. Psychol.* 34:297-323, 1983.