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Editor's Note

Multiple memory systems

Investigations of the extent to which memory is distributed or localized in the brain have held a central focus throughout the history of psychology. The hypothesis that memory formation occurs among specialized regions of the brain has gained support in the last several decades due primarily to reports of dissociations among brain regions specialized for acquisition and storage of various kinds of information. While dissociations suggest independence among multiple memory systems, an increasing number of reports indicate that memory systems may interact cooperatively or competitively.

The present special issue of *Neurobiology of Learning and Memory* had its origins in a satellite symposium titled "Independence and Interaction among Multiple Memory Systems" held in conjunction with the 2003 meeting of the Society for Neuroscience in New Orleans, Louisiana. Other authors have contributed to this issue in addition to those who presented papers in the symposium. While the techniques and methods used by the authors vary widely and represent several levels of neurobiological analysis, all of the authors study the dynamic nature of learning and memory across multiple brain areas. This approach will likely reshape our understanding of the neurobiology of learning and memory and suggests that memory systems may, under different conditions, collaborate in novel ways, modulating both what and how much is learned.

The extent of agreement among the authors regarding interactions among memory systems is perhaps surprising considering the breadth of theoretical and methodological approaches to the issue. An assumption of the multiple memory systems hypothesis is that there is some degree of specialization among memory systems and many of the authors make similar conclusions about the functional organization of these systems. How we define a memory system, however, remains in question even as our knowledge of the cellular and molecular underpinnings of memory systems has increased rapidly. And while there is general agreement on specialization among memory systems, recent evidence suggests that specialization may be more evident at the systems than the cellular level of analysis.

The development of this field of research began by descriptions of modules for processing different types of learning and memory identified on the basis of double dissociations of brain area by task, then by triple and higher dissociations. These analyses led to the important set of findings that damage to some modules can at times improve learning of tasks handled by other brain areas, results suggesting that memory systems may exhibit considerable interdependence, characterized often as competition between and cooperation across systems. Several recent approaches to the issue of multiple memory systems have involved examinations of the activity of different systems assessed by neurochemistry, cell and molecular biology, and functional imaging. Because the neural systems are intact during these measures, this latter approach permits identification of changes in the balance between modules on-line, or nearly so, during memory formation.

Many of the important questions and hypotheses regarding interactions among memory systems are just now being formulated. Some examples include how systems interact across time, with shifting cognitive strategies, and under differing motivational components. The extent to which interactions occur during learning and during guidance of behavioral output has also recently been investigated. Shifts in cognitive strategies and in the activation of the respective neural systems, have been identified in a variety of contexts, including across the lifespan, in brain damaged victims, neurological and psychiatric disorders, with hormonal cycles in normal subjects and in subjects under the influence of various drugs including substances of abuse. In examining the relative activation of different memory systems, another question that arises is whether there is a hierarchical arrangement by which one system dominates others. If so, is this hierarchy fixed or is it flexible, responding to such variables as

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aging, hormonal cycles, stress, as well as to damage and pathologies? Related to this point, the findings of several of the papers in this special issue of *Neurobiology of Learning and Memory* suggest, even at this early stage of the evolution of thinking about multiple memory systems, that the balances between memory systems contribute to individual differences in styles of learning and in processing of new memories.

It is clear from this collection of papers that we will progress most rapidly toward understanding the dynamics of interactions among memory systems by a coordinated, interdisciplinary effort. This special issue of *Neurobiology of Learning and Memory*, which we have co-edited, is intended as an early step in that direction and as a means toward identifying important emerging issues regarding the extent to which multiple memory systems are independent or interactive.

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