

Hippocampal formation and the classical art of memory

Formation and consolidation of declarative memories depend on the physiology of the hippocampal formation. Moreover, this brain structure determines the dynamic representation of the spatial environment, thus also contributing to spatial navigation through specialized cells such as “place” and “grid” cells (1). The most interesting recent results by Jacobs et al. (2) further this research field by showing that the entorhinal cortex contains path cells that represent direction of movement (clockwise or counterclockwise). The authors underscore that neurons in the entorhinal cortex encode multiple features of the environmental and behavioral context that can then be memorized by means of operations carried out by the hippocampus. They conclude by suggesting that a fuller characterization of these neurons’ properties and relation to the hippocampal circuit will be necessary to understand the neural basis of cognition. I fully agree with their conclusion and wish to comment on a further aspect of this complex issue, by considering psychological evidence that traces back to the ancient world and is generally neglected by modern neuroscience.

Greek and Roman culture has handed down to us the so-called “art of memory,” a set of methods aimed at improving one’s memory, described in detail by Cicero, Quintilianus, and others. The history of these concepts and their multifarious cultural meaning was masterfully treated by Rossi (3) and Yates (4). In brief, committing to memory long written pieces, word lists, series of numbers, etc. is greatly facilitated by proceeding as follows. First, one chooses a series of objects or places located in a (preferably familiar) spatial environment, such as the architecture details of a building or the landmarks of a certain route. Subsequently, these objects or places are mentally associated to the items to be remembered. The map of environ-

mental images, which is easy to recall, thus provides a direct hint to the more abstract items. Moreover, proceeding along such a mental path directly provides the proper order of the sequence to be memorized (say a poem or speech). For example, Cicero used to associate the main points of his long speeches to specific buildings or other topographical reference points along the familiar route to the Roman Forum.

This method still constitutes the basis of modern mnemonics, which must be deeply rooted in neurology because it seems to be applied unawares even by mnemonists who have never heard of its existence. A famous example is the one described by Luria (5), who was himself unaware of the art of memory. Such venerable psychological evidence makes the neurophysiological association between orientation in space and declarative memory in the hippocampal formation even more suggestive. It supports the notion that the consolidation of human memory is guided by a partially preconfigured system related to external space representation, which may be the evolutionary basis of memory processing of more abstract entities in complex brains. These considerations may also have heuristic value in suggesting how the entorhinal cortex, the hippocampus, and the neocortex interplay during memory consolidation of complex abstract issues.

Andrea Becchetti¹

Department of Biotechnology and Biosciences, University of Milano–Bicocca, Piazza della Scienza, 20126 Milan, Italy

1. Moser EI, Kropff E, Moser MB (2008) Place cells, grid cells, and the brain’s spatial representation system. *Annu Rev Neurosci* 31:69–89.
2. Jacobs J, Kahana MJ, Ekstrom AD, Mollison MV, Fried I (2010) A sense of direction in human entorhinal cortex. *Proc Natl Acad Sci USA* 107:6487–6492.
3. Rossi P (2006) *Logic and the Art of Memory* (Continuum International, London).
4. Yates F (1992) *The Art of Memory* (Pimlico, London).
5. Luria AR (1986) *The Mind of a Mnemonist: A Little Book About a Vast Memory* (Harvard Univ Press, Cambridge, MA).

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¹E-mail: andrea.becchetti@unimib.it.