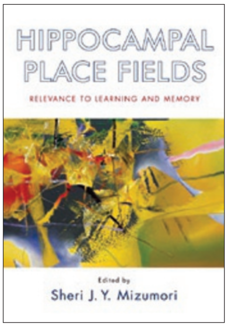
Celebrating place cells



Hippocampal Place Fields: Relevance to Learning and Memory

edited by Sheri J Y Mizumori

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Reviewed by Douglas Nitz

I doubt that anyone, scientist or not, ever forgets his or her first encounter with a place cell. Typically, one watches the movements of a rat foraging in an environment while a single-neuron recording from that rat's hippocampus is played through a speaker. The rat mills about and suddenly the low-volume crackle of background activity is replaced by the loud pop of action potentials when the rat enters a specific region of the environment. Place-specific firing is arguably the most robust single-neuron phenomenon one can observe in an awake, freely behaving animal. The experience is an eye opener that has changed the career path of many young neuroscientists.

I imagine that Sheri Mizumori had such an experience in the 1980s when she joined Bruce McNaughton and Carol Barnes at the University of Colorado. Now a veteran place-cell researcher at the University of Washington, Sheri's enthusiasm for place cells and what they tell us about learning, memory and hippocampal function is clearly expressed in her work. This is particularly evident in the chapters she co-authors in her recent book *Hippocampal Place Fields: Relevance to Learning and Memory*. Actually, one senses this enthusiasm regularly from the authors throughout the book.

Someone peering in from another scientific field might appreciate the attraction to place cells but also might ask why a mere firing correlate is the subject of an entire book. The answers are found throughout the book. Put simply, place cells are now an important reference point from which to address a host of issues in neuroscience. The subtleties of their behavior are used to examine many aspects of brain function, including gene expression, synaptic plasticity, spatial awareness, cognitive impairments associated with aging, attention, rule-learning, temporal binding and episodic memory.

The broad reach of place-cell research probably stems from the fact that the discovery of place cells by O'Keefe and Dostrovsky in 1971 coincided with three major developments in memory research. At about the same time, David Marr published theoretical work linking unique features of hippocampal anatomy to principles of memory encoding and recall. Earlier work by Scoville and Milner had identified the hippocampus as critical for episodic memory. Finally, Bliss and Lomo were soon to demonstrate long-term potentiation of synaptic connections, the backbone of virtually all theories of memory encoding. To this day, each development serves as a powerful guide to the design of place-cell experiments. In many of the chapters in this book (for example, chapter 19), we see that place cell experiments have, in turn, helped to bridge the gap between these different levels of analysis. For instance, we now know that action potentials from different place cells are timed in such a manner that they continually reflect the sequence of places visited by the animal. Thus, place-cell activity reflects the behavioral episode associated with visiting any given place. The same neuron-to-neuron timing of action potentials is optimal for induction of long-term potentiation in hippocampal circuits. In conjunction with each hippocampal subregion's unique anatomy, such potentiation allows the hippocampus to have a special role in memory encoding and recall.

The timing of this book's publication is near perfect. Until recently, for example, little place-cell data was available to corroborate ideas concerning the specific role of hippocampal subregions in memory processes such as pattern separation and completion. Moreover, the field was unaware of hippocampally projecting cells in entorhinal cortex that show multiple firing fields arranged in a grid formation. Chapter 15, written by Marianne Fyhn, Trygve Solstad and Torkel Hafting, explains why the discovery of 'grid' cells has markedly changed ideas as to the origin of place-specific firing in the hippocampus. Reading through a chapter by Amy Griffin, Howard Eichenbaum and Michael Hasselmo and another by Inah Lee, Raymond Kesner and Jim Knierim, one now gains confidence that an understanding of the fundamental relationships between subregions is nearly in hand.

Equally evident is that place cells are a useful tool for understanding memory impairments associated with aging. Chapters written by Iain Wilson, Heikki Tanila, Sara Burke and Carol Barnes focus on place cells in aged animals and reveal a recent convergence in the findings from two independent research programs. Specifically, aged animals have trouble updating their positional mapping with visual cues. Finally, there is now a wealth of data helping to bridge the gap between two major theoretical positions on hippocampal function. As described in Kathryn Jeffery's chapter, extreme versions of each see the hippocampus as either a tool to map space or to encode memory. Indeed, recent experiments have suggested that these positions are not incompatible. In the first section of the book (chapters 1–11), a thorough presentation of work from several laboratories reveals that, to a surprisingly large extent, the place-specific activation of hippocampal neurons is modulated by the different types of experience associated with any particular region of an environment.

The book's organization reflects Sheri Mizumori's deep understanding of the fact that place-cell research is much less a specialization than a field that adeptly speaks to scientific questions ranging from molecular biology to cognition. Ranging from historical background to the current leading discoveries and theories concerning place cells, this book is well-situated to be a resource for graduate-level students of the field as well as for nonspecialists. The chapters of this book offer a wonderful opportunity to see the interface between sensory and motor systems, the interaction between cellular and network properties of the hippocampus, and the underpinnings of learning and memory as they relate to the hippocampus. ■

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