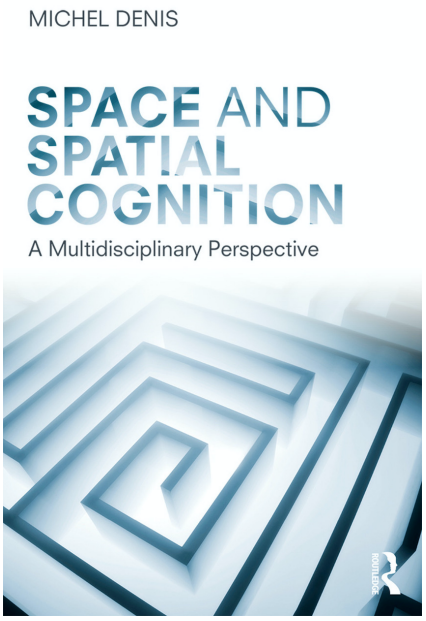

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Space and Spatial Cognition:
A Multidisciplinary Perspective

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Foreword
Space and spatial knowledge

There is no living creature that eludes the issue of its inscription in space and its moving across it. For all animal species, moving is an imperative condition for survival, a fact that justifies the study of spatial behavior to be at the heart of life sciences. Research in this domain first draws on observation and involves a variety of behavioral measures. It extends with the formulation of hypotheses about the internal representations that people build of space and the identification of their brain infrastructure. Joint understanding of behavior and of the cognitive and neurobiological mechanisms that subtend it is the guiding thread of most research programs dedicated to this field. In any case, it is mine.

The area

The title "Space and Spatial Knowledge" is intended to stress that beyond the analysis of the properties of *space* as an object of study in its own right – as promoted by mathematicians, philosophers, geographers, and others, – a major challenge consists in understanding how living organisms acquire *spatial knowledge* and build representations that form the basis of their behavior. For a scientist, it is by their behavior that people ultimately express their knowledge of space. Establishing correspondences between behavioral markers and cognitive processes is the essence of the approach to be illustrated here.

There are multiple "sizes" of space, ranging from proximal space as it is captured by sight, like the page displayed on my computer screen, the surface of my desk, or even the room environment that surrounds me, to large-size environments that can only be known by moving around and experiencing a succession of perspective takings, as is the case with cities, regions, continents. This variety of "scales" raises the issue of establishing whether the representation of different spaces calls for distinct cognitive processes or is governed by the same single set of cognitive capacities.

A related issue is to establish whether or not spatial cognition constitutes a special domain of cognition. Some approaches may reflect the inclination for interpreting spatial cognition as a "module" with its specific structures and processes. Alternatively, rather than being an isolated entity within the cognitive architecture, the representation of space is seen as a function interfaced with the whole domain of human cognition, first of all perceptual and sensorimotor functions, extending to memory, learning, and reasoning.

Space, as a research area, places demands on disciplines that make use of diverse methodologies. In the recent years, it has proved to be a highly multidisciplinary domain. The representation of space offers a privileged example of a field of research where a high number of disciplines converge, with a special contribution from those adopting the perspective of cognitive science.

Not only is space a topic actively investigated by a number of scientific communities, but within each discipline, there is an expression of curiosity and interest about what the other disciplines tell about it. For this reason, even a book written with an initial disciplinary perspective – in the present case, cognitive psychology – cannot omit addressing issues that are relevant for other disciplines. This book has been planned with the ambition of gathering those pieces of knowledge that are relevant for life sciences, but also social sciences, language sciences, and computational sciences.

The book

The book adopts a point of view that recognizes primary, although non-exclusive, value to knowledge collected by behavioral sciences. This knowledge has been enriched and illuminated by data stemming out of many other disciplines, in particular neuroscience, linguistics, and computer science. The idea here was not to produce a formal textbook, but instead to provide a selection of solid findings resulting from a variety of empirical approaches. To serve this objective, the book has been organized around five thematic packages (each containing three chapters).

As a point of departure, I thought it relevant to consider *space as an object in itself* (Part I). The issue of space has been thoroughly investigated by generations of philosophers. It is also an essential component of geometry, as part of mathematics dedicated to the study of figures in space. Geography, on its side, is guided by the objective of accounting for how territories designed by nature and eventually reshaped by human history are distributed across space. In the final chapter of Part I, architecture and pictorial creativity are directly confronted with problems related to the expression of space in the creation of visual forms.

Space is also to be seen as a set of *environments where action takes place* (Part II). It offers a context in which a variety of behavioral instantiations unfold, such as reproducing travel, planning a trip, discovering a shortcut, and many others. Such behaviors are submitted to analyses that lean on the use of specific methodological tools. These analyses substantiate the theoretical accounts of the cognitive processes underlying spatial behavior. This is the subject of the second part of the book, which documents the behavioral counterparts of critical concepts, such as spatial reference frames and cognitive maps.

As a natural continuation of this approach, Part III reviews the brain mechanisms responsible for spatial cognition and behavior. The development of neuroimaging techniques has expanded our knowledge of the functions and dysfunctions of the *spatial brain*. The analysis extends to the diseases which affect spatial cognition and navigation when *sensorimotor systems* are damaged. Special consideration is given to the situation faced by people suffering visual impairments and to the efforts put in the development of navigational aid systems.

Part IV deals with *communication about space*. Beyond cartographic representations, much of spatial information can be expressed through verbal and digital forms of communication. While the previous two parts deal with knowledge and practice of space through the prism of action and behavior, in Part IV we tackle the issue of space as approached by linguistics and semantics. The question is to assess how spatial information is expressed not only in an analog format (where space is represented by space, subject to a change of scale), but through natural or digital languages.

Lastly, Part V deals with *computational sciences* and the broad range of *technologies* currently developed with the aim of building devices and exploiting spatial databases, with special attention to those intended to serve human action, such as wayfinding in unfamiliar environments. As in many other domains of human-machine communication, engineers are confronted with the issue of optimizing the adjustment of their systems to the users' cognitive capacities. New spaces opened by virtual technologies, as well as challenges met by research in robotics, will also be discussed in this fifth and last part.

When completing this scientific journey at the crossroads of a range of disciplines, an epilogue will give me the opportunity to wave the readers and do my best to convince them of the virtue of *spatial thinking*.

* * *

While writing this book, I could not avoid the feeling that the breadth of the subject and the variety of entailed questions might justify a more ambitious academic volume, a tentative *Treatise of Sciences of Space*. As a matter of fact, edited books have been published in the last years in the United States, but all remained confined to psychological and neurocognitive approaches (cf. Postma & van der Ham, 2017; Shah & Miyake, 2005; Waller & Nadel, 2013). However, a multidisciplinary perspective is essential in this domain and obliges us to adopt an approach that goes beyond solely brain and behavior sciences. Special consideration is due to the multidisciplinary approach illustrated in a book on geographic information systems and how their design must take data related to human behavior into account (cf. Richter & Winter, 2014).

The present volume reviews theories and data collected by scientists who belong to a range of disciplines, taking care that none of the major questions related to space are left aside. Each chapter can be seen as a key opening a door on a conception or a particular facet of spatial cognition. It is my wish that the amplitude of the topics discussed and the coverage of disciplinary approaches that are practically never illustrated in books written by psychologists

open stimulating perspectives. These questions are treated in the form of compact, coordinated chapters in which more than half of the cited works have been published since the beginning of the twenty-first century, and which summarize the essentials of current knowledge on space and spatial cognition.

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