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**Imagery, Language,
and Visuo-spatial Thinking**

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Preface

Visual imagery and visuo-spatial memory play key roles in the higher cognitive functions of mental representation, of creative thinking, and of planning complex actions, as well as contributing to understanding of differences in mental ability. This volume presents discussions of current theories and empirical endeavours driving these dynamic areas of research. Each chapter is jointly authored by leading European researchers from five different laboratories (Orsay, France; Aberdeen, Scotland; Padova, Italy; La Laguna, Spain; and Saarbrücken, Germany) which have been part of a significant, and extended collaborative effort within the context of a European Union funded partnership under the Human Capital and Mobility Programme. The programme allowed a level of scientific interaction and exchange of scientific personnel that is extremely rare in cognitive psychology, enabling the significant co-ordinated effort of five physically distant and distinct laboratories to be devoted to complementary scientific questions. The achievements of this partnership have been disseminated in the scientific literature, through the now well established biennial European Workshop on Imagery and Cognition, and through the European Society for Cognitive Psychology as well as at national and international conferences in Europe and in North America. This volume collates the disseminated work in the form of theoretical and empirical reviews while taking advantage of the medium to extend theory, to report ongoing work, to speculate a little, and to explore a few possible areas of application as well as of science.

The focus is on recent research across European laboratories, but each chapter has clear pointers to the highly influential data and theory from North America that have dominated thinking on imagery since the early 1970s, allowing the more recent European as well as American work to be set in context. The involvement in each chapter of authors from different laboratories offers a degree of coherence and cross-referencing that would be difficult to achieve with independent contributions. The chapters each address key aspects of the properties and functions of imagery as basic components of human visuo-spatial thinking, from mental discovery to helping plan actions and routes, from making sense of and remembering our immediate environment through to generating pictures in our mind from verbal descriptions of scenes or people, and from the discussion of how individuals differ in their ability to use imagery through to the neuropsychological and neuroanatomical correlates of imaging in the brain.

In Chapter 1, **David Pearson**, **Rosanna De Beni**, and **Cesare Cornoldi** address fundamental questions as to how mental images are generated, maintained, scanned, and transformed, as well as how images appear to support the processes of mental discovery. The questions have been explored within the context of quite different theoretical frameworks, notably the computational model developed by Kosslyn and his colleagues, and the working memory model developed by Baddeley, Hitch, Logie, and others. The chapter illustrates clearly how each model addresses different empirical questions with the former conceived as a model of mental imagery while the latter is a model of part of the cognitive system which supports a range of cognitive tasks, including the generation, maintenance and transformation of images.

In Chapter 2, **Tomaso Vecchi**, **Louise Phillips**, and **Cesare Cornoldi** explore the individual differences in visuo-spatial working memory that might serve as indicators of mental ability. They discuss research on imagery in the maturing minds of children and in individuals facing learning disability, on visuo-spatial cognition in the ageing minds of adults, on the nature and use of imagery in the blind, on visuo-spatial ability in adults who have suffered cognitive impairment following brain damage, and on the impact of cognitive expertise on the use of imagery strategies. The theoretical discussions again include the Kosslyn model and visuo-spatial working memory, but there is in addition a new theoretical perspective based on whether imagery tasks have a dynamic or a passive emphasis.

Chapter 3 examines the importance of implicit or explicit aspects of cognitive representation, with a detailed treatment by **Johannes Engelkamp**, **Hubert Zimmer**, and **Manuel de Vega** of the perceptual and conceptual coding of words and pictures. Images involve both the surface features of objects and scenes and the meanings and associates of objects in the scene. In implicit memory tests in which a subsequent memory test is not expected, memory performance is typically dependent on physical properties and largely independent of conceptual processing. This led researchers to assume that physical properties of stimuli are decisive in implicit tests, whereas meaning is decisive in explicit tests where participants are aware that memory for the material will be assessed. However, it turns out that meaning also plays a role in implicit tests and that physical properties can be retrieved in explicit tests. This chapter offers an explanation that draws on the perceptual–conceptual distinction as well as on the construct of episodic integration and on the specific mode of retrieval in explicit tests.

In Chapter 4, **Oliver Turnbull**, **Michel Denis**, **Emmanuel Mellet**, **Olivier Ghaëm**, and **David Carey** discuss some of the detailed studies of cognitive impairment in people who have suffered from brain damage, as well as some of the recent studies using both neuroscience and neuroimaging techniques to examine the neuroanatomical correlates of mental imagery. This is a fascinating combination of neuropsychological and brain-imaging techniques that is starting to reveal not only the functional organisation of imagery, its links with perception and how it breaks down following brain damage, but also the mapping of these important cognitive functions onto areas and pathways in the brain. The structures of the occipito-parietal system (the dorsal "where" or "how" stream) appear to be involved in deriving information about the spatial location of objects, and the process of visually-guided action. In contrast, the structures of the occipito-temporal system (the ventral "what" stream) seem to be involved in deriving information about the identity of objects, from the process of object recognition. The evidence converges on the

general conclusion that object recognition and spatial abilities are achieved by relatively independent neural systems.

The principles that govern the links between language and the mental representation of space are explored in Chapter 5 by **Manuel de Vega, Marguerite Cocude, Michel Denis, Maria José Rodrigo, and Hubert Zimmer**. These researchers discuss the forms of spatial representations that people generate following their perceptual experience or following a verbal description. One part of the discussion is focused on the sensory-motor system that appears to involve fine-grained representations that have the properties of Euclidean space. This is thought to govern navigation in the environment, and the grasping and manipulation of objects. A second aspect of the discussion is of a system thought to direct pointing to objects in the current environment. The mental imagery system forms a third topic, referring to a spatial simulation system that allows people to build Euclidean representations of layouts and mental analogies of movement such as rotation and scanning, and this mental simulation appears somewhat independent of the current perceptual environment. A fourth element is the topological system, thought to be associated with the comprehension and production of verbal descriptions involving categorical and relational representations of space. Finally, there is discussion of a metaphorical system that permits the mapping of complex verbally based relations into spatial relations. The chapter describes and evaluates the wealth of experimental evidence addressing all of these five proposed aspects of the links between language and visuo-spatial cognition and how the different levels of representation are thought to interact.

Chapter 6 explores experiments, theory and potential applications to navigation. **Michel Denis, Marie-Paule Daniel, Sylvie Fontaine, and Francesca Pazzaglia** discuss how people use a variety of sources of information for constructing their spatial knowledge: navigation through their environment, visual inspection of surrounding space, processing of cartographic information, and processing of verbal descriptions of spatial environments. The use of this last source of information requires a close link between the processing of language and the visuo-spatial representational system. Although both systems have quite different structural and functional properties, they cooperate efficiently in a wide range of natural contexts. The authors review empirical data collected in experiments on the production and comprehension of spatial discourse, with special reference to situations where language is used for the purpose of providing navigational aids in unfamiliar environments. Cognitive processes involved in the production of route directions are analysed experimentally in an attempt to identify the factors that determine effective communication. The experiments involve judges' ratings of the effectiveness of verbal route descriptions and also the use of the route descriptions in navigating through complex urban environments, including the labyrinthine streets and alleyways of Venice.

In Chapter 7, **Robert Logie, Johannes Engelkamp, Doris Dehn, and Susan Rudkin** complete the book by discussing research findings that point to links between physical enactment, imagined enactment, and memory for actions. Some of this literature has focused on the association between actions and aspects of episodic and semantic memory. A parallel theoretical development has been the suggestion that one component of working memory (as discussed in Chapters 1 and 2) provides cognitive support for the planning of actions and immediate memory for movements. The authors address the possible theoretical contributions which can be drawn from the working memory literature to account for aspects of memory for actions. In so doing, they explore the role of working memory in remembering and planning actions as well as the associations between working memory and long-term storage.

A common theme throughout the book is the development of theories of visuo-spatial thinking in the context of thorough experimentation. The result is a volume that intends to serve both a tutorial function through thoughtful reviews of each sub-area, as well as offering a coherent statement of current developments. The human cognitive system appears to comprise interacting, specialist subsystems that can successfully address a wide range of everyday cognitive tasks. This book has arisen from interacting, specialist subgroups of researchers coming from different scientific cultures in different laboratories in different countries. The common object of their study, visuo-spatial cognition, is complex and diverse and the insights achieved thus far have capitalised on the diversity of approaches and expertise that the authors

represent. We hope that this volume will be persuasive in illustrating the level of scientific productivity that can be achieved through orchestrated international collaboration.

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