THE SENSES: A COMPREHENSIVE REFERENCE

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Volume 1
VISION I

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Academic Press is an imprint of Elsevier
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, UK
525 B Street, Suite 1900, San Diego, CA 92101-4495, USA

First edition 2008

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Catalog Number: 2007939855

ISBN: 978-012-639482-5

For information on all Elsevier publications
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Printed and bound in Canada

07 08 09 10 11 10 9 8 7 6 5 4 3 2 1

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Introduction to Volumes 1 and 2

We have tried in these two volumes to cover most of the major topics in visual neuroscience, starting from molecular fundamentals and progressing to perception and cognition. We are fortunate to begin with an essay by Gerald Westheimer, one of the founders of the modern field and a scholar of great depth. The first volume continues with chapters on visual ecology and the mechanics of vision in animals other than mammals – comparative subjects that should inform thinking about all aspects of vision in any species. Our colleagues in those areas have outdone themselves and we are grateful for their thorough and entertaining contributions.

The chapters on the mammalian retina are, in general, shorter and more focused. In selecting the authors we have sought the leaders and innovators in each specialized area and we are fortunate that so many of them are represented here. We have urged them to provide continuity in their chapters and believe that they succeed in creating a deep and coherent portrait of the circuitry and fundamental functions of the retina. The final chapters of this volume leave the retina and enter the brain. They ask: where does the output of the retina go next, and what happens to it in the early stages of central vision? Here, we begin to encounter some of the limitations of current methods, notably that studies of visual coding have lagged behind the gains made using molecular and imaging techniques. A striking example is our inability to specify the different visual coding patterns transmitted to the brain by the approximately 12 structural types of retinal ganglion cells. Current approaches to the coding problem are illustrated in several chapters; but the problem is far from solved and represents a major task for the next generation.

The second volume moves beyond brain structures and mechanisms involved in light detection, retinal processing, and low-level analysis of visual image features, to address central representations associated with the perceptual interpretation of visual images. In recent years, visual neuroscience has made great strides in understanding how salient visual attributes are represented in the cerebral cortex. Recent advances are reflected here in an extended series of chapters written by leaders in their respective subfields, which collectively explore the cortical representations of luminance, color, motion, and shape. Consistent with one of the major recent trends in the field, these chapters do a fine job of integrating data and comparing perspectives gained via visual psychophysics, neurophysiology, and functional brain imaging.

In addition to representing and abstracting key properties of visual attributes, such as color and motion, vital processing stages in the visual cortex include (i) extracting the spatial layout of surfaces in the visual scene and (ii) recognizing objects. The former falls under what has come to be called 'mid-level visual processing' and recent progress is reflected here in a chapter on the topic of surface depth ordering by cues for transparency and occlusion. Object recognition, by contrast, has long been regarded a facet of 'high-level visual processing'. We have included an extended chapter that canvasses this captivating subfield with timely discussions of visual memory and perceptual constancies. One particularly intriguing and well-studied aspect of high-level vision is face recognition, and we have included a chapter that delves into this topic in some detail.

Among the most important discoveries in central visual processing over the past couple of decades is the degree to which neuronal representations of visual attributes are modifiable by shifts of attention and by experience. The field of visual attention has been particularly prolific and we have accordingly included a series of detailed chapters that address varieties of attention and their neurophysiological manifestations in the visual cortex. Perceptual learning – an experience-dependent change in the way visual features are represented –

is an emerging area of study, and we have included a chapter that nicely interweaves evidence regarding perceptual effects, neuronal response properties, and underlying mechanisms.

Finally, one of the main functions of visual processing is to influence movements of the body. Sensorimotor integration and plasticity are broad areas of study, which deserve their own volume, but we have included herein an article on a topic that is both representative of the field and one of its most deeply plowed zones – the vestibulo-ocular reflex (VOR).

The breadth and depth of topics addressed by the chapters in these two new volumes on the visual system attest to the fact that this field has developed greatly since the time Donald Hebb observed that "we know virtually nothing about what goes on between the arrival of an excitation at a sensory projection area and its later departure from the motor area of the cortex." In recent years, much of this development has been driven by technology – for example, the use of ever-better techniques for cell labeling and tracing of neuronal connections, and the refinement of procedures for recording neuronal activity in behaving animals. A long-awaited bridge has also been extended between the fields of experimental psychology and physiology, which has lead in part to a powerful union of visual psychophysics and cellular neurophysiology.All indications are that the next edition of these volumes will contain chapters that build on still newer technical and conceptual developments, such as the large-scale application of molecular genetic tools to probe visual functions at the systems level, and the use of imaging techniques that enable monitoring of activity simultaneously from large populations of neurons. Indeed, we have much to look forward to.

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