Reviews

Weighty and timely neuroscience
The new visual neurosciences edited by J S Werner, L M Chalupa; MIT Press, Cambridge, MA, 2013, 1696 pages, $250.00 cloth (£172.95) ISBN 9780262019163

Physically, The New Visual Neurosciences is a monster, over 1600 pages and 3.5 kg. It is actually a few pages shorter than the first edition (The Visual Neurosciences, 2003), but division into two volumes made the earlier book more manageable to handle. The format has not basically changed from that edition—a large number of shortish chapters, ranging from retinal neurotransmitters to scene perception, written by authoritative and active researchers, mostly based around their own research programmes but with a strong and valuable review element. But the content is quite new: some whole sections have gone, and some new ones, such as “Objects and scenes” and “Translational visual neurosciences” have appeared; there are many new authors (Dennis Levi, Fred Kingdom, and Gillian Rhodes are among those likely to be well known to Perception readers); and chapters that were present in the first edition have been extensively revised, often gaining additional authors. So if you wanted or needed the first edition, you will need or want the new one.

The editors, in their introductory chapter, describe the volume as “a comprehensive review of the vast progress in the past decade” (page 1). Perception researchers may reflect ruefully that the pace of change seems to be more astonishing in neurobiology, notably of the early stages of the visual pathway, than in psychophysical and perceptual studies of ‘higher’ visual function. In the former domain, those who are sufficiently broad minded will find plenty to reflect on—or, at least, revise their lecture notes. If you thought that magno and parvo cells were the be all and end all of functional division in the retina, chapter 13 by Roska and Meister will introduce you to 20+ different types of retinal ganglion cell, each forming a mosaic which transmits distinctive information to the brain. If you tell your students that the LGN transmits to the cortex much the same information as it receives from the retina, a series of chapters will explain how it operates in two radically different modes—alerting the cortex in ‘burst mode’ and faithfully transmitting in ‘tonic mode’—and participates in thalamocortical loops which allow the cortex to modulate its own input, sharpening, tuning, and selectively adjusting transmission according to attention and overall state of arousal. If you were not yet aware of the mouse as a key model for visual system organisation, chapters 18 by Burkhalter, Sporns, Gao, and Wang and 29 by Niell, Bonin, and Andermann (and mentions in many others) will assure you that mice have joined cats and monkeys in providing new information to dissect the network of visual brain areas.

Whatever your focus within the mechanisms of vision, you will find a concise, up-to-date review chapter. To pick examples of more perceptual topics, more or less at random: Brainard and Radonjić (chapter 38) provide a crisp overview of the issues in explaining colour constancy, including the problems that are posed by specular reflection and varying angles of viewing a surface; Whitney, Haberman, and Sweeney (chapter 49) review the evidence on human abilities to extract the ‘ensemble statistics’ of an array of positions, orientations, faces, or motion patterns; Oliva (chapter 51) examines the ability to extract the gist of a scene (indoors?, street?, woodland?, beach?) and the brain areas which contribute to it; Johnston (chapter 53) analyses the different kinds of time judgment that we make in vision, and the role of temporal filters in subserving them; Orban and Mastorf (chapter 55) take us through the multiple pathways which analyse motion-based information in the brain, and their commonalities and differences between humans and macaques; Sasaki and Watanabe (chapter 69) consider the conditions that promote perceptual learning, and the associated effects in different brain areas; Martinez-Trujillo and Khayat (chapter 77) present evidence for neural interactions that provide a basis for feature-based, and not just location-based, attentional amplification; Kersten and Yuille (chapter 88) discuss how far Bayesian statistics help us to understand the rationale for a variety of visual processes. And on, and on! If you can dip into this book for three or four pages, and not find something you didn’t know but feel you ought to, then you are either an astonishingly well-informed or a rather blinkered visual scientist.
Is it truly perfect? Well, no book, much less a multiauthor compendium, can quite be. Everyone will find some omission. A largish one is that the new “Translational neuroscience” section on clinical applications is almost wholly focused on the ophthalmology of the retina; neurological and neuropsychological issues are largely omitted both here and in the other sections, with ‘neglect’ and ‘blindsight’ absent from the index, and ageing restricted to macular degeneration. Human neuroimaging is the main subject of 4 chapters out of 112, and while it figures in a number of others, this still doesn’t seem to fully represent its impact on the visual neurosciences in the last decade. And a somewhat surprising omission (given the emphasis on single-unit studies elsewhere in the volume) is recent work unravelling representations in the primate ventral stream (for example, Pasupathy and O’Connor on shape descriptors, and Tsao on the network of multiple face areas).

Assembling and organising 200-odd authors must have been a herculean effort for the editors, not to mention a triumph of good judgment and ferocious networking. Inevitably, there is some unevenness of treatment. Some chapters present a focused argument, while others are more like catalogues of topics or results where one might welcome a few more paragraphs of synthesis. However, my sampling (this reviewer cannot lie; he has not read every page) revealed no duds or potboilers, and overall there is a remarkable degree of coherence and well-planned organisation. The end product is rather like having a bumper classified collection of well-chosen articles from Trends in … or Current Opinion in …: a taster of hot topics and key controversies, and a tremendous route into the current literature. Readers who find themselves engaged in any of the topics will find a wealth of guidance for that route, and will need to follow it if they are to judge the full significance of the issues they encounter in the chapters here. We can be very grateful for that guidance: you would not have to plough through many issues of Journal of Neuroscience, Journal of Vision, or Vision Research to exceed the 1600 pages here; your indigestion would be much worse, and you would have learned much less.

The volume is designed and produced to the usual high standard of the MIT Press. A change from the first edition is that the colour illustrations are no longer segregated in a glossy insert, but appear like other figures close to the relevant material in the main text. The resulting quality is not quite as good, but the gain in convenience, and in the use of colour material to illustrate results and theories, is well worth it. So far only the previous edition seems to be available on MIT Press CogNet system. It is not clear whether this is a commercial decision or just a slow process: but for those lucky enough to have institutional access to CogNet, an iPad would certainly be easier than 3.5 kg of paper, for happy and rewarding browsing in bed.

Oliver Braddick
Department of Experimental Psychology, University of Oxford, South Parks Road, Oxford OX1 3UD, UK; e-mail: oliver.braddick@psy.ox.ac.uk

Galileo’s visions: Piercing the spheres of the heavens by eye and mind by M Piccolino, N J Wade;
Oxford University Press, Oxford, 2014, 336 pages, £39.99 cloth (US $65.00) ISBN 9780199554355

In 1609 an optical instrument consisting of two lenses mounted at the extremities of a long tube, which permitted seeing things far up in the sky so clearly that they appeared as if they were right in front of the observer, was delivered to the city of Venice. Although this strange new object was much admired by the Venetian socialites, essentially for the beauty of its design, nobody seemed to see much more in it, or would have guessed what was going to happen. One man saw the object’s potential, took it, and set it to work. He began observing the moon and the stars through it for long hours. The man’s name was Galileo, a professor of mathematics from Padua who was about to change the course of history and, in the process, was to become a heretic in the eyes of the Church. Through that optical instrument, the telescope, Galileo would gain knowledge that was to shatter the established vision of the cosmos and give way to a new world order, one where man was to occupy a much more peripheral place. Looking at the heavens through that telescope, with a piercing mind behind his eyes, would enable Galileo to predict how the Earth was likely to look when seen from the moon, centuries before NASA was to produce the first satellite images. It would lead him to understand some of the most fundamental interactions between light and matter, the limited ability of our senses, and the many ways in which the physical environment determines our perception of reality.

Should you be tempted to think “oh no, not another book about Galileo”, you should reconsider. This new book entitled Galileo’s Visions, by Marco Piccolino and Nick Wade, starts where other books
have stopped. It tells us everything about Galileo that you will not find on Wikipedia. Beginning with
the tale of the delivery of the telescope to Venice, the authors take us on a journey through Galileo’s
private intellectual universe, from his thought experiments about the luminance of the moon to the
man’s early insights into the complex interactions between light and matter, based on his observations
of nature. These preceded Newton’s (1704) conclusion that there is no colour without light, and
Newton’s own colour theory, by almost a century, and the discovery of structural colour in biological
tissue of animal species (eg Dresp & Langley, 2006; Osorio & Ham, 2002) by four centuries.

Step by step, accompanied by witty visual artwork by Nick Wade, we are made familiar with
Galileo’s early intuitions about physical and perceptual phenomena, addressed by science only centuries
later. Transcripts of the man’s private writings include fictive conversations where his alter ego Salviati
addresses Sagredo, a Venetian aristocrat and like-minded friend, frequently interrupted by Simplicio,
a fictional character, eager defender of classic cosmology. In those days of intellectual darkness, when
Simplicio and the rest of the world believed that the Earth was flat and that there was a day and a
night because the sun travelled around it, Galileo nursed his own ideas about the universe and physical
reality, and he produced a series of texts, which are the basis of this book. These texts deal with man’s
extraordinary ability to gain insight into complex physical phenomena through systematic observation
of nature. Such ability provided him with an understanding, well ahead of its time, of the ways in
which our brain perceives the world. In the allegorical language of fables, Galileo recounts the voyage
that leads the human mind to knowledge. Through extracts from these fables, we discover what he
already knew then, about the importance of individual experience in our capacity to discriminate
and produce sounds (eg Claude, 2007), for example. We learn about different, diffuse or mirror-like,
reflections of the world, and that there is a difference between the visual mechanisms of seeing objects
that reflect light and objects that do not (eg Jacobs, 2008).

In a series of thought experiments, Galileo articulates comparisons between the brightness of
the sun and that of the moon, under varying conditions. These thought experiments not only led him
to infer that the Earth illuminates the dark part of the moon more than the moon illuminates the
earth, but also led him to understand lightness constancy (Gilchrist, 2006) and simultaneous contrast
(Chureul, 1839), physiological optics, and the importance of being able to recognize objects under
varying conditions of illumination, or reflection of light from these objects. Galileo had insight into the
effects of aerial perspective (Ross, 1967) and relative object size on our perception of what appears
nearer and what appears further away from us, well before Leonardo da Vinci (1651) listed them in his
Trattato della Pittura as two of the most important monocular cues to visual depth. He knew a lot about
the physical nature of light and the phenomenon of diffraction (Bragg & Bragg, 1915) well before
ultraviolet and infrared wavelengths, which the human senses cannot perceive, were discovered and
measured. Also, it appears that Galileo had opinions on Copernicus’s and Kepler’s theories which may
surprise more than a few. Galileo knew that the size of the moon and the stars would be overestimated
when viewed through a telescope at night, and one of the problems he set out to resolve late in life
was that of determining the relative position of the moon and the stars more accurately, on the basis of
experiments comparing observations at night and during the day. However, this was not to be, as his
failing vision finally compromised these plans.

I very much enjoyed reading this book, which is all about a professor of mathematics with an
aversion to formalism, and a strong attraction to nature, to the animal kingdom, to phenomena of lights
and shadows, to art, and to literature. I would have enjoyed the pictures in the book even more had
they been printed in colour. The lacklustre monochrome representations do not seem to do their author
justice. Yet, what the image reproduction lacks in hue, the storytelling makes up for by an entertaining
style, rich in details and references. You will not tire of it.

Recently, scientists have discovered new particles that do not seem to obey conventional laws of
physics (Bazavov et al., 2014). Phenomena such as brain-to-brain communication (Grau et al., 2014)
are now being investigated in respectable research laboratories, and it seems that there are still so
many limitations to our knowledge, maybe more than we realize—be it about the universe or about the
capacity of our brains to perceive and communicate. If Galileo lived today, his piercing mind would
definitely have to be reckoned with!

Birgitta Dresp-Langley
ICube, UMR 7357 CNRS, Université de Strasbourg; e-mail: birgitta.dresp@icube.unistra.fr
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