Review: *Vision And Brain : How we perceive the world* by James V. Stone, MIT Press

I loved this book. A highly readable and accessible introduction to vision, it is distinctive in its emphasis on the computational principles underlying our visual perception.

This emphasis is laid out uncompromisingly in the first chapter. Rather than starting with the anatomy of the retina, the book begins by convincing the reader that vision is hard and inherently ambiguous. A succession of striking visual illusions helps Stone make the case that, although visual perception appears effortless to us, it is in fact an unexpectedly challenging problem, whose solution involves more assumptions and outright guesses than logical deductions. Stone ends the chapter by laying out Marr's famous three levels of analysis, arguing that the computational (or informational) principles are as important to understanding our vision as a knowledge of the neuronal hardware.

In the next three chapters, Stone does take us through the neuronal hardware: the anatomy of the eye, the projections from retina to thalamus to visual cortex and so on. But at every stage he is concerned to bring out the underlying computational principles. The on/off-centre receptive fields of retinal ganglion cells are not just described as experimental facts, but related to push-pull processes for achieving linearity. We learn about Fourier analysis and Taylor's theorem as well as orientation columns and cytochrome oxidase blobs.

As befits the title (Vision and Brain, not Vision and Eye), there is relatively little detail on retinal circuitry (amacrine, horizontal, bipolar cells are not mentioned, for example) or phototransduction, but a whole chapter on Bayesian inference. While I welcomed this chapter in principle, in practice I felt it was one of the less successful parts of the book. The treatment is a little non-standard, delaying the introduction of noise until relatively late. I found the text rather involved and hard to follow, especially the discussion of Fig 6.4, and could not recommend this as an introduction to Bayesian theory.

This was uncharacteristic, because throughout most of the book the text is exceptionally enjoyable and easy to follow. I liked the unashamed poetry of Stone's language. Each chapter begins with a quotation, followed by a couple of sentences of "Impressions", sometimes in rather purple prose. For example: *Vast plains of gray, a virtual famine of information, a desert bereft even of redundant data. An arc of pure light sears itself into the retina, abutting an arc of darkness, creating a long cliff edge of light, and the famine is over.* I found some of these Impressions more successful than others, but they provided a refreshing change of pace. The book is full of striking images; for example, that "a neuron is like a wineglass", because it resonates with its preferred input. As well as figures and diagrams to aid comprehension, it includes pictures which are not strictly "necessary" but serve to break up the text and make key points more memorable, e.g. a picture of the Wright brothers' 1902 glider to illustrate Marr's point that "trying to understand vision by studying only neurons is like trying to understand bird flight by studying only feathers."

In summary, this book is an excellent addition to the range of introductory texts available in vision science. I will certainly be recommending to my students, undergraduate and postgraduate.

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How we perceive things is a very broad topic to attempt to fit into a book of only 224 pages. The anatomy of the eye, the nervous reactions and impulses from retina to visual cortex, and the various different aspects of perception (such as colour, contrast, and, the most fickle, depth) have enough detail in them to take up a book of more pages alone themselves. However Stone does a brilliant job of summarising everything in very neat packages before giving the information out in a structured, scientific way that very rarely patronises the reader while ensuring that even the most complex concepts can be broken down into simple analogies that undergraduates, postgraduates and post doctorates could relate to and understand on any 'sticky' topics they suffer.

Stone starts with an introduction to the concepts discussed with many helpful illusory diagrams to underline the concepts he is talking about, with a brief outline on why the eye perceives these illusions as such, without going into too much detail or going off on a tangent from the track of the book. The diagrams themselves are well presented and the accompanying paragraphs provide a very clear representation of what each figure is there for. The next few chapters study much of the biology associated with the eye, covering topics such as the evolution of the eye itself, the way neurons send out signals and the mechanisms used to transmit images from the retinal field to the mapping in the cortex. Much of this information is simplified, and small anecdotes provide a breakdown for anybody without a high enough standard of biological knowledge for the more complex subjects. A running theme throughout the books is the comparisons between computers and the work involving numbers. Stone regularly refers back to the concept of *computational theory*, strongly proposed by Marr, about the actual mechanism used to perform a task being unimportant, but the reason or function behind the task being the most imperative aspect to look at, and also quotes various speeds and sizes cited throughout. The chapter focussing on depth perception towards the middle of the book takes a closer look at the way the brain and eye cooperate to transform a 2D mapping into a 3D representation of the space around us using cues from the environment and the aid of stereovision. The chapter very cleverly splits our depth cues into the various aspects before piecing the jigsaw together in the conclusion.

The book then moves on to the statistical model that the brain and eye appear to follow in the decisions on what the retina is portraying to what we are actually 'seeing': Bayesian inference. Stone explains and discusses the broad concepts and background of Bayesian statistics in a nutshell, and how they can be applied to vision and how research has indicated that indeed the visual system does rely on Bayesian inference. While the book covers all the key areas well there should have been more page space allocated for writing out the equations correctly and maybe highlighted that the constant can be removed and a proportional sign can be swapped for an equals sign, with maybe a couple of easier, purely mathematical examples to show how the numbers might fit into it all. That said the content is all there and explained well for anybody in the scientific field with some, but not much, statistical background knowledge.

The information coding chapter was for the most part very interesting. The chapter goes into details about the way the information from the brain can be compressed using information theory. Reading about how the ganglion cells encode the information in bits, albeit a simplified explanation was both stimulating and thought provoking. The simplifications made the reading a lot more manageable and the examples taken through were both short and clear. The way this chapter linked in with previous chapters in the book was also nice, as it reinforced ideas already covered in the book. The final part

of the chapter about colour opponency, although only briefly touched upon, was the clearest explanation I have yet to see in any book or paper.

The book closes on the various deficiencies that the brain can suffer from, including the various forms of agnosia that Stone describes from the viewpoint of suffering patients, goes into detail very well, from a different angle to normal, why the brain sees as it does, via the independence of the visual characteristics the brain responds to. Stone goes into clear detail about the different low and high-level parameters (page 213-219).

Finally, Stone goes on to explain his own personal stance on the field of visual science and explain he worries soon "we are in danger of ending up wandering around inside a silicon chip, knowing the inputs and outputs but without understanding *how* each component transforms…nor *why* such…is desirable". He goes onto express that as scientists we should ask for more than just an explanation of the mechanisms of vision, but also the underlying computation that goes on around it. This is a view I find particularly interesting, and one that could be applied to many other aspects of biology, particularly the other sensory systems. The further reading Stone suggests at the end of his writing leaves no doubt to the reader that this is very much an overview of the different facets of vision that can be researched, although a chapter by chapter further reading may have been helpful, had somebody had only one particular part of the book they wanted to explore further.

Vision And Brain has compiled various important aspects of human perception in a clear, thorough and succinct way. Stone's to-the-point explanations make every page worth reading twice and his anecdotal way of explaining the more complicated concepts lends itself well to this book being used at any level. The topics covered delve just deep enough to raise many a complicated question and then proceed to answer just a handful. I would argue that the book could in fact be read even by non-academics who just had a slight interest in the eye and how they see, however the price may put them off when there are cheaper alternatives or free sources such as Wikipedia that they could use. That being said any academic who wonders if the book is worth the £20.95 price tag for only 224 pages would not be disappointed. As a postgraduate student from a maths background I found the information was delivered at a good level of understanding and with enough detail for me to grasp the ideas but not get lost in the details. I particularly thought the figures and mathematics lent themselves well to the book, as they were put in at the right moments and not used simply as illustrations to stop the reader from becoming bogged down with the amount of words they were reading. Stone has done an excellent job of bringing together many pieces of the visual puzzle, putting them together, and showing the bigger picture in an engaging, concise and accessible way for any audience of readers, be they undergraduate or post doctorate.

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