Christopher Mole, **Declan Smithies**, and **Wayne Wu**, eds.
Attention: Philosophical and Psychological Essays.
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Explaining attention is a big job. Some headway has been made in *Attention: Philosophical and Psychological Essays*, which comprises fourteen chapters—five by psychologists and neuroscientists, and nine by philosophers—and an introductory essay by the editors. Some of the contributions are reviews of parts of the scientific literature by neuroscientists and psychologists; among these, some fail to engage with the broader metaphysical issues, and thus could be found as review chapters in a neuroscience or psychology handbook. But the majority here describe broad philosophical implications of theories of attention as well as their empirical foundations.

In modern psychological science, the notion of 'attention' can encompass the experience of being engrossed in an object, tracking multiple objects, searching for an object in a scene, binding together the features of objects, extracting spatial relationships between objects, referring demonstratively to objects, distributing cognitive resources amongst objects, tasks or regions of space, and other phenomena besides. Over a century ago, already some were despairing that the concept of attention was so manifold as to have little content. Christopher Mole's chapter on the metaphysics of attention includes a concise historical overview with some choice quotations on the matter, including one from F. H. Bradley writing in 1886: 'Any function whatever of the body or the mind will be active attention if it is prompted by an interest and brings about the result of our engrossment with its product. There is no primary act of attention, there is no specific act of attention, there is no one kind of attention at all.' (65) Mole's conclusion is that 'the explanation of attention must take a form other than the process-specifying form that is the favourite of cognitive psychologists' (66).

Mole adopts an adverbial definition of attention that he calls *cognitive unison*. Motivated by similar considerations, other philosophers writing for this volume also argue for a definition not tied to a specific process or set of processes. Of course, the danger in explaining attention so broadly is that the eventual theory ends up too abstract to provide a useful guide for empirical work. But if a definition that includes everything we should like to mean by attention is necessarily one that does not specify a process, it is important to get that straight. Otherwise, we scientists may persist in pursuing attention in a way that will never settle the issue.

An important decision faced by every theorist is whether consciousness is necessary for attention. In this volume, Sebastian Watzl defines attention as *structuring the stream of consciousness*; and Declan Smithies identifies it with *rational-access consciousness*. But empirical work over the last few decades has yielded several phenomena that are sometimes described as 'attention without conscious awareness'; most striking are claims for perceptual benefits that derive from unconscious cues (see Tsuchiya & Koch's review at http://www.scholarpedia.org/article/Attention_and_consciousness/attention_without_consciousness). Jesse J. Prinz also places attention in a particular relationship to consciousness: specifically, he proposes that *attention is necessary and sufficient for consciousness*. The argument for

necessity rests on empirical evidence from patients with unilateral neglect following damage to right parietal cortex, and the psychological phenomena of inattentional blindness and the attentional blink. In these cases, it appears to be the absence or withdrawal of attention that renders stimuli unconscious. The argument for sufficiency rests on empirical examples of attentional capture such as visual pop-out and attentional cueing. Prinz only briefly addresses recent evidence that suggests attention is *not* sufficient for consciousness, but indicates that his recently published book provides a full treatment (*The Conscious Brain*, Oxford University Press 2012).

Robert Kentridge provides an extensive discussion on the relationship of consciousness to attention-like empirical phenomena. As a researcher who has worked directly with patients with blindsight, his contribution is likely to be especially valuable to philosophers. Every chapter here written by a philosopher refers to blindsight; most contain extended discussion of it. Why is it so important? As Imogen Dickie explains, 'in blindsight there seems to be selective processing of information from objects of which the subject is not aware' (299). This apparently complete dissociation of attention, consciousness, and action is where many of the distinctions among different theories of attention are most stark.

In part of Alan Allport's contribution to the present volume, he addresses the binding problem. Different features of the visual world (for example, colour and shape) are to some extent processed by distinct neural populations. To achieve our coherent experience (*this* is a red triangle, *that* is a green square), some aspect of brain function must link the associated neural populations so that we know which colour goes with which shape. Allport's chapter might give the impression that neuroscientists have established that this is accomplished via synchronous firing of associated neural populations. However, strong evidence for this theory has not been found despite much work over recent decades, and some evidence contradicts the theory (M. N. Shadlen & J. A. Movshon, 'Synchrony unbound: A critical evaluation of the temporal binding hypothesis', *Neuron* 24 [1999]: 67–77; A. Thiele & G. Stoner, 'Neural synchrony does not correlate with motion coherence in area MT', *Nature* 421 [2003]: 366–370).

For Wayne Wu, attention is *selection for action*; his account is heavily influenced by Allport's influential theoretical essay ('Selection for Action: Some Behavioral and Neurophysiological Considerations of Attention and Action', in *Perspectives on Perception and Action*, Lawrence Erlbaum Associates 1987, 395–419). For those interested in better understanding how the processing of a simple organism can evolve to allow selection for action, we recommend the work of Ward and Ward on artificial evolved agents ('Representation in dynamical agents', *Neutral Networks* 22 [2009]: 258–266).

As several contributors note, one hallmark of attentional processes is that they appear to compete for limited resources. When a person deliberately allocates more attention to one task than to another, performance will improve on the former task and decline on the latter task if the two tasks share a common attentional resource. Here we will leave aside the issue of whether apparent resource limitations are best understood as an emergent property of competitive interactions in cognitive processing, a view defended by Allport. It might be that the myriad phenomena described as attentional are all limited by a single processing bottleneck, or by a manageable number of bottlenecks; if this were the case, we could work on defining attention by

reference to these, and premise research on this definition. Braun and colleagues have tested whether different visual tasks are limited by a common resource, although this work may have been overlooked by the contributors to this volume. Among tasks such as judging the colour of a disk, the direction of rotation of an ellipse, the relative position of two disks of known colour, or the direction of motion of a plaid disk, Braun and colleagues have found that performance trades off in a way that is consistent with the tasks drawing on the same undifferentiated resource (A. Pastukhov, L. Fischer, & J. Braun, 'Visual attention is a single, integrated resource', *Vision Research* 49 [2009]: 1166–1173). The claim is controversial and it is unclear whether the results will generalise to other sensory modalities such as audition and touch. The literature on whether tasks in *different* modalities use the same resource is especially immature, though the field is rapidly developing.

Over the last two decades, the theorist and experimentalist Zenon Pylyshyn has argued that one ability, object tracking, is particularly key to understanding attention and how the mind connects to the sensory world. The philosopher Imogen Dickie entitles her chapter 'Visual attention fixes demonstrative reference by eliminating referential luck'; she was evidently strongly influenced by Pylyshyn's theoretical work on object tracking. Object tracking experiments are typically intended to provide insights into the nature of our capacity limit for tracking several moving objects. A key question is whether multiple objects are processed in parallel or instead one-by-one; most of the chapter by Srimant Tripathy, Haluk Ogmen and Sathyasri Narasimhan is devoted to this issue. Tripathy and colleagues advocate the unpopular (but viable, in our view) position that the changing locations of targeted objects are updated one-by-one rather than in parallel. Since they wrote their chapter, new evidence has appeared that is consistent with their serial view (A.O. Holcombe & W.-Y. Chen, "Splitting attention reduces temporal resolution from 7 Hz for tracking one object to <3 Hz when tracking three", *Journal of Vision* 13 [2012]), but other recent evidence seems more consistent with parallel tracking (P.D.L. Howe, M.A. Cohen, & T.S. Horowitz, 'Distinguishing between parallel and serial accounts of multiple object tracking', *Journal of Vision* 10 [2010]).

Less controversial is that the capacity limitation on tracking is not, in fact, a single limit. Rather, there are independent limits in the left and right regions of visual space: tracking additional targets in one visual hemifield has little to no effect on tracking performance in the other (G. A. Alvarez & P. Cavanagh, 'Independent resources for attentional tracking in the left and right visual hemifields', *Psychological Science* 16 [2005]: 637–643). Thus any serial account will in fact require two one-by-one processes, occurring in parallel, one in each hemisphere. In contrast, other attentional tasks such as visual search do not seem to draw on hemifield-specific resources. This suggests that there are at least two stages of processing bottlenecks, and future work will determine which attentional processes are limited by inter-hemispheric resources, and which by intra-hemispheric resources.

Empirical evidence of attentional capacity limits has been used to argue that conscious experience has higher capacity than cognitive representation. In advancing this view in 1995, Ned Block wrote that 'perceptual consciousness overflows cognitive access' (for an update see N. Block, 'Perceptual consciousness overflows cognitive access', *Trends in Cognitive Sciences* 15 [2011]: 567–575).

In the present volume, Ian Phillips mounts an interesting challenge to Block's notion that many more things are experienced than can be reported or attended. His primary example is George Sperling's iconic memory paradigm, in which a large array of items is presented very briefly. Only a subset of the items can be reported on any one trial; and that subset can be varied by cueing the location of the items to be reported, even after the array has disappeared. This finding has led to the inference that all of the items are *experienced*, albeit transiently, with the capacity of the processes required to *report* the items being more limited. As Phillips points out, this assumes that the experience of the array is set and unchangeable by the time of the cue. But it has long been known that the experience of one stimulus can be affected by another that follows it by a few to several hundred milliseconds (D. Dennett & M. Kinsbourne, 'Time and the observer: The where and when of consciousness in the brain', *Behavioral and Brain Sciences* 15 [1992]: 183–247).

A substantial empirical literature now exists on such phenomena, which are sometimes called 'postdictive'. Phillips argues that extended durations constitute the basic units of experience, durations that in Sperling's paradigm would include both the array *and* the cue. Thus the experience of the cue is related to the experience of the array without any need to conclude that the entire array was in any way experienced. An empirical study published after the release of the book has increased—not to say *postdictively* increased—the plausibility of this account. Using a single visual stimulus presented too dimly to be seen, Sergent and colleagues found that cueing its location nearly half a second later substantially improved its visibility (C. Sergent, V. Wyart, M. Babo-Rebelo, L. Cohen, L. Naccache, & C. Tallon-Baudry, 'Cueing attention after the stimulus is gone can retrospectively trigger conscious perception', *Current Biology* 23 [2012]: 1–6). This would appear to demonstrate that attention can change the experience of stimuli presented in the past, further questioning the assumption that the entire array is experienced in the iconic memory paradigm. Perhaps consideration of these results will shift other philosophers in a Phillipsian direction.

The philosopher Campbell engages deeply with a recent psychological theory of visual attention: the *Boolean map* theory of L. Huang and H. Pashler ('A Boolean map theory of visual attention', *Psychological Review* 114 [2007]: 599–631). Campbell hopes to 'tie consciousness of a property to the possibility of selecting on the basis of that property', arguing that one cannot experience a stimulus without also experiencing the property that distinguishes it from its background. He uses the example of a colour-defined digit, and suggests it is impossible to perceive the digit without also having some perception of its colour. Campbell may not be aware of scientific results that have been used to argue precisely the opposite. P. Cavanagh, M.-A. Henaff, T. Landis et al. ('Complete sparing of high-contrast color input to motion perception in cortical color blindness', *Nature Neuroscience* 1 [1998]: 242–247) reported on patients who were colour blind because of damage to the cerebral cortex (this contrasts with more common cases of colour blindness which are due to differences in the retina). Despite profound loss of the subjective experience of colour itself, they were able to recognise the motion of contours defined solely by colour. The point here is that unconscious processes can make use of certain cues (e.g., colour) to construct other percepts (e.g., motion); thus we can be aware of objects or motions without awareness of the cues that were used to detect them. There are other difficulties in understanding the relationship between conscious access to visual properties and attentional selection of them. Boolean map theory does not provide a comprehensive solution. When we

view a smooth gradient from black to white, the theory predicts that each luminance value is experienced one-by-one. This is difficult to reconcile with our experience of being simultaneously aware of the entire gradient. Still, Boolean map theory has been exciting in its scope, apparent simplicity and concreteness, so other philosophers would do well to consider it.

Some philosophical theories of attention are intensely concerned with empirical facts about the way in which our conscious experiences are connected to the outside world. Science is steadily accumulating results that are useful in developing and testing those philosophical theories. Many of these results were reviewed by the experimentalists contributing to this volume. The philosophers' analyses in this volume should help to reduce confusion among experimentalists and help to specify what we should be striving for in our science of attention.

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