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The Eye's mind – Visual imagination, neuroscience and the humanities

Adam Zeman [a,*], *Matthew MacKisack* [a] *and John Onians* [b]

[a] *Cognitive Neurology Research Group, University of Exeter Medical School, St Luke's Campus, Exeter, UK*
[b] *Department of Art History and World Art Studies, University of East Anglia, Norwich, UK*

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Visual imagery, evoking the appearance of things in their absence, is, for most of us, a conspicuous ingredient of everyday experience. The capacity to summon images to the mind's eye appears to play a major role in memory, daydreaming and fantasy as well as in creative thinking by scientists, writers and artists (Schacter & Addis, 2007; Smallwood & Schooler, 2015). Evidence from cognitive psychology supports a functional role for imagery in cognition, while cognitive neuroscience has begun to delineate the brain regions and networks that subserve it (Pearson, Naselaris, Holmes, & Kosslyn, 2015). However, its distinctive contribution to cognition has been questioned (Kosslyn, Thompson, Ganis, 2006), and a recent report (Zeman, Dewar, & Della Sala, 2015) has reinforced Galton's contention (Galton, 1880) that a small minority of the population – with lifelong 'aphantasia' – lack conscious visual imagery entirely. This Special Issue, was inspired by a unique interdisciplinary project and associated conference: it approaches the vibrant topic of visual imagery from a range of complementary perspectives, with contributors from cognitive and clinical psychology, philosophy, neuroscience, computer science, art and art history and literary criticism.

Our back-to-front title, The Eye's Mind, originates in a project funded during 2015 by the British Arts and Humanities Research Council (AHRC). It brought together the editors of this Special Issue (Zeman, a neurologist; MacKisack, a historian of ideas; Onians, an art-historian) with the artist Susan Aldworth; philosopher, Fiona Macpherson and neuroscientist, Crawford Winlove. The three strands of its activity were i) a review of the history of thinking about visual imagery and its place in cognition (see (MacKisack et al., 2016)); ii) a meta-analysis of functional imaging studies of visual imagery, published in this issue (Winlove et al., 2018); iii) an initial attempt to characterise the experiential, behavioural and neural associations of 'extreme imagination', occurring in individuals who report either the complete lack of visual imagery, or its superabundance. During the year of the project, a related paper (Zeman, Dewar, & Della Sala, 2015) reporting 21 individuals with lifelong absence of the mind's eye and coining the term 'aphantasia', attracted a high degree of press and public interest: since then around 11,000 individuals with aphantasia or its counterpart, hyperphantasia have made contact with the Eye's Mind team. In May 2016 the initial phase of our project culminated in a two-day conference at the University of East Anglia, linked to the Sainsbury Centre for the Visual Arts. All but two of the papers in this Special issue are based on or closely related to work presented there.

Given the interdisciplinary nature of the topic and of the conference that inspired this Special Issue, its contributions are unusually – and deliberately – varied. Visual imagery plays a pervasive role in our experience: we consider it here in the context of 'ordinary cognition', as for example in Bence Nanay's example of the 'involuntary and unconscious' visual processing that occurs when we hear our noisy percolator at

* *Corresponding author*. Cognitive Neurology Research Group, University of Exeter Medical School, St Luke's Campus, Exeter, EX1 2LU, UK.
E-mail addresses: a.zeman@exeter.ac.uk (A. Zeman), M.MacKisack@exeter.ac.uk (M. MacKisack), j.onians@uea.ac.uk (J. Onians).
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work next door (Nanay, 2018); in the context of atypical cognition, as in the paper by Nick Watkins, describing his own lifelong lack of imagery and autobiographical memory impairment (Watkins, 2018); in the context of emotion, as in the paper by O'Donnell et al. on the role of imagery in modulating mood (O'Donnell et al., 2018); and in the context of aesthetic appreciation and creation, as when we read novels (Brosch, 2018), or make art (Aldworth, 2018; Onians, 2018; Horváth, 2018). Our contributors employ a wide variety of approaches, including first person reports (Watkins, 2018; Aldworth, 2018), brain imaging (Winlove et al., 2018; Fulford et al., 2018), measurement of eye movements (El Haj & Lenoble, 2018), behavioural measures (Keogh & Pearson, 2018; Jacobs, Schwartzkopf & Silvanto, 2018; Hossain, Simner & Ipser, 2018; Chang & Pearson, 2018; O'Donnell et al., 2018), computer modelling (Kunda, 2018), philosophical analysis (Nanay, 2018), historical review (Horváth, 2018; Mackisack, 2018; Onians, 2018) and creative reflection (Aldworth, 2018).

Several key themes emerge from the papers published here. We open the issue with two papers on the neural basis of visualisation. Visual imagery has been a popular focus for studies using non-invasive brain imaging which has transformed our collective ability to study previously elusive mental processes in the living human brain, but there has been no recent attempt to synthesise what we have learnt in relation to imagery. The opening paper of this issue, by Winlove et al. takes on this challenge, reporting the results of an Activation Likelihood Estimate (ALE) meta-analysis of 40 neuroimaging studies of visualisation. The brain network identified by this study implicates areas associated with vision itself, but also with semantic memory, eye movements, attention and executive control, underlining the complexity of visualisation and highlighting candidate regions for further study. The neural theme is taken further by Fulford et al. who report the findings of a brain imaging study targeted specifically on imagery vividness, placing these in the context of the handful of other studies with the same remit.

Variations in imagery vividness are relevant to our second theme, the occurrence of 'extreme imagery'. Nick Watkins illuminates the experience of extreme imagery with his personal account of aphantasia associated, in his case, with a marked reduction in memory for previous autobiographical events: he was one of the four subjects described in a recent paper identifying a 'syndrome of severely deficient autobiographical memory' or SDAM (Palombo, Alain, Soderlund, Khuu, & Levine, 2015). Three other papers examine aspects of exceptional imagery: Keogh & Pearson use the innovative binocular rivalry paradigm (Pearson, Clifford, & Tong, 2008) to obtain an objective measure of imagery strength in 15 participants with aphantasia, providing evidence that these individuals indeed lack the phenomenal experience of visual imagery; Jacobs, Schwartzkopf & Silvanto study working memory in a single participant with aphantasia, reporting an impairment of high precision visual working memory performance. These papers pave the way toward establishing objective neuropsychological correlates for aphantasia, a phenomenon first clearly reported by Francis Galton (Galton, 1880) but strangely neglected over the intervening century. At the other extreme of the vividness spectrum, Hossain, Simner & Ipser study participants with synaesthesia, who have been reported, as a group, to possess more vivid than average imagery, reporting an association between the trait of Openness and the saturation of synaesthetic colour experiences.

The use of informative and innovative methods in the scientific study of imagery provides a third intertwined theme. We have already highlighted the use of brain imaging in elucidating the neural basis of imagery. Joel Pearson's binocular rivalry paradigm (Pearson et al., 2008), devised to obtain an objective measure of imagery strength, is applied in two papers from this Special Issue: by Keogh & Pearson in the context of aphantasia, as outlined above, and by Chang & Pearson in a study indicating that imagery of motion, like imagery of static visual features, can influence subsequent perception. El Haj & Lenoble measure eye movements during past and future thinking and relate their results to the difference in reported imagery vividness between the two forms of thought. Kunda considers how visual imagery could be implemented in an artificial intelligence system and what such an implementation might achieve, following Richard Feynman's dictum that 'what I cannot create, I do not understand'. Approaches like these, combined with electrophysiological methods, not represented here, provide powerful tools to probe the neurocognitive substrates of imagery.

The fourth theme is the relevance of imagery to experience and behaviour beyond a narrow definition of 'cognition'. Hossain, Simner & Ipser's paper, mentioned above, links the experience of synaesthesia with personality. O'Donnell et al. focus specifically on interrelationships between imagery vividness and mood in individuals with subclinical features of bipolar disorder. The relevance of extreme imagery, in particular, to affect, psychotherapy and education are fertile topics for future investigation, with potential practical importance.

The two final themes move us from cognitive and neural science into the humanities. It has been a guiding principle of the Eye's Mind project that crossing freely between these territories can enrich research on both sides of the divide. Two papers exemplify this by using historical and philosophical approaches to illuminate normal and pathological aspects of imagery: MacKisack explores the history of thinking about visual and verbal forms of representation, symbolised by Plato's metaphors of 'Painter' and 'Scribe', relating them to clinical cases of imagery loss; Nanay makes the case that multisensory imagery is a ubiquitous ingredient of everyday perception.

Finally, four papers consider imagery in the context of artistic creation and appreciation. For many of us, fiction conjures up a visual world. Brosch reviews relevant evidence, relating this experience, and variations in its intensity, to the concept of the ventral and dorsal pathways within the visual system, the 'what' and 'where' – or 'how' – streams. Aldworth, the artist member of the Eye's mind team, provides a salutary reminder that the standard scientific concept of 'visualisation' falls well short of what an artist is likely to mean by 'imagination'. Onians and Horváth develop this theme by exploring several kinds of imagination relevant to art, while pointing to some neural processes that help to explain them.

We should not conclude without highlighting the significance of the fact that Cortex, one of the longest-running and most prestigious journals of neuropsychology, is including contributions from non-scientists within its pages. Lip-service is often paid to 'interdisciplinarity', but the meeting of science and the humanities can be reductive: science 'answering' a question within the humanities, or art simply depicting science's findings. In this Special Issue we see a genuine enmeshing of approaches. Philosophical conceptual analysis, historical contextualisation, and first-person experience are entering into scientific discourse, into the way scientific knowledge about the mind is produced. Rather than compromising hard-won values, the addition of perspectives both expands and sharpens that knowledge: 'a way of seeing', as Kenneth Burke noted, 'is also a way of not seeing' (Burke, 1984, p. 35).

We hope that the papers collected here will illustrate the interest, breadth and excitement of the interdisciplinary study of visual imagery. Anyone wishing to learn more of the continuing work of the Eye's Mind project can visit its website at http://medicine.exeter.ac.uk/research/neuroscience/theeyesmind/.

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