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(A)phantasia and severely deficient autobiographical memory: Scientific and personal perspectives

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ABSTRACT

I address two interlinked aspects of the diversity in our experiences of memory and the mind's eye. I summarise the long-appreciated role of imagery in mathematics and the physical sciences, and contrast it with the evidence that some scientists have had limited or zero imagery. I then recount the story of how I became aware of my own lack of mental imagery, and the accompanying deficit in my episodic memory, how I have sought scientific understanding of these conditions, and how they have affected my life.

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1. Introduction

The contributions in this special issue touch on many of the areas of human creativity in which visual imagery has played a key role, and my paper, derived from my contribution to the "Eye's Mind" conference in 2016 supported by the AHRC, aims first to briefly survey the role of imagery in mathematics and the physical sciences, but it also has a second, more personal aim.

Three human visual capacities are so familiar that most people take them for granted: i) visual imagination in a "mind's eye", ii) an "episodic" aspect to memory that travels back in time to give a first person sense of experiencing again one's own past sights, sensations and emotions, and iii) its opposite, first person "mental time travel" into an anticipated future. But we really shouldn't be so blasé. Indeed it has been argued (Tulving, 2002) that episodic memory and the first-person sense of time are among the most remarkable

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products of evolution. Because the faculties noted above are so universal, they can be taken to be essential aspects of being human, but in the last two years it has become much more widely appreciated that a significant number of people actually lack mental imagery ("aphantasia"; Zeman, Dewar, & Della Sala, 2015), and that some otherwise healthy people have severely deficient autobiographical memory (SDAM; Palombo, Alain, Soderlund, Khuu, & Levine, 2015). I am one such person. I have been aware of my aphantasia and SDAM, and I have been seeking to understand the reasons behind them for almost 20 years. The rest of this paper gives a report of my findings (albeit an unusual one in which first person testimony will figure large).

2. Scientific aspects

The role of the nearly universal human faculty of mental imagery (Kosslyn, 1994; MacKisack et al., 2016; Pearson, Deeprose, Wallace-Hadrill, Burnett Heyes, & Holmes, 2013; Thomas, 1997) in scientific and mathematical creativity has long attracted research interest (Brewer & Schommer-Aikins, 2006; Ferguson, 1977; Hadamard, 1945; Mancosu, Joergensen, & Pedersen, 2005; Miller, 1986; Rocke, 2010). Probably the most celebrated instance is the physical chemist Kekule's account (Benfy, 1958; Rocke, 2010) of how he dreamt the structure of the benzene ring: "*long rows, … all twining and twisting in snake-like motion … One of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes. As if by a flash of lightning I awoke; and … spent the rest of the night in working out the consequences of the hypothesis*" (Benfy, 1958). By his own account, such visualisation was a frequently exercised faculty, his "*mental eye*" having been "*rendered more acute by repeated visions of the kind*". The benzene dream was apparently preceded by an earlier daydream on a London bus about chemical valence, where "*the atoms were gamboling before my eyes*" (Benfy, 1958).

Many physicists have employed visualisation, for example space scientist Jim Dungey, interviewed in 1986 saying "*I saw the picture … in three dimensions, whereby the electric field over the polar cap fitted in with the reconnection picture … Then, I think if I can, everybody can*" (Dungey, 1986). Albert Einstein seems to have been an archetypal visualiser. His most famous thought experiment, to imagine riding alongside a beam of light, was conducted as a 16-year old student at a Pestalozzi school in Switzerland (Isaacson, 2015). Many years later he responded to a questionnaire about scientific creativity by the French mathematician Jacques Hadamard [see Appendix II of Hadamard (1945)] by saying *The psychical entities which seem to serve as elements in thought are … more or less clear images which can be 'voluntarily' reproduced and combined. [Some are] of visual and some of muscular type. Conventional words or other signs have to be sought for laboriously only in a secondary stage*."

Pauli even went as far as collaborating with Jung to investigate the latter's "primordial images" as the bridge between sense perceptions and concepts (Zabusky, 1984). However, even enthusiastic users of mental imagery have urged caution. Kekule, after all, warned us to "*beware of publishing our dreams until they have been tested by the waking understanding*". Although Farmelo (2009) reports that Dirac was "*always uneasy with algebraic approaches to physics and with any mathematical process he could not picture*", it is striking that he nonetheless prefaced his "Principles of Quantum Mechanics" by saying: "*the laws of physics do not govern the world as it appears in our mental picture in any very direct way, but instead they control a substratum of which we cannot form a mental picture without introducing irrelevancies*" (Dirac, 1930). Although Feynman greatly admired Dirac, his famous diagrams were a direct response to the latter's implicit challenge to find a pictorial tool that could be of value in quantum mechanics (Wuetrich, 2010).

The training of physicists recapitulates the historical process, and generations of students have struggled with the transition between Newtonian mechanics and Maxwell's electrodynamics, where many concepts benefit greatly from visualisation, and quantum mechanics, a theory constructed using objects as foreign to our direct sensory experience and intuition as the probability amplitude wavefunction which solves Schrodinger's equation (e.g., Longair, 2003; Miller, 1986).

The rigour exemplified by the scientific method is of course essential to making science as objective as possible, by detaching its conclusions from the thought processes of any one individual, no matter how exceptional, and subjecting them to experimental test. In mathematics, where proof rather than experiment is the final arbiter, an even more fundamental disdain for visualisation has existed in some quarters. Lagrange for example proudly said "*you won't find any drawing in my book*", while the collective of French mathematicians who published as "Nicolas Bourbaki" sought to eliminate any need for visualization, part of a broader distrust of geometry in proof. In Marjorie Senechal's interview (Senechal, 1998), Bourbaki founder member Pierre Cartier gives this fascinating reply to her question about the sources of this disdain: "*… The Bourbaki were Puritans, and Puritans are strongly opposed to pictorial representations of truths of their faith. […] So, what were the reasons? The general philosophy as developed by Kant, certainly. […] And then there was the idea that there is an opposition between art and science. Art is fragile and mortal, because it appeals to emotions, to visual meaning, and to unstated analogies. But I think it's also part of the Euclidean tradition. In Euclid, you find some drawings but it is known that most of them were added after Euclid, in later editions. Most of the drawings in the original are abstract drawings. You make some reasoning about some proportions and you draw some segments, but they are not intended to be geometrical segments, just representations of some abstract notions. […] The analytical spirit was part of the French tradition and part of the German tradition. And I suppose it was also due to the influence of people like Russell, who claimed that they could prove everything formally—that so-called geometrical intuition was not reliable in proof*."

In stark contrast to the Bourbaki was a mathematical visionary (and visualiser) Benoit Mandelbrot, whose own uncle was one of the founders of the Bourbaki, and whose life's work was in some sense a riposte to their approach. Describing the way in which he mastered mathematics as a teenager he said: "*I didn't learn much algebra. I just learnt how better to think in pictures because I knew how to do it. I would see them in my mind's eye intersecting, moving around or not intersecting and could describe what I saw. Having described it, I could write two or three lines of algebra, which, is much easier if you know*

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