Studies in History and Philosophy of Science 64 (2017) 53–63

Contents lists available at ScienceDirect

Studies in History and Philosophy of Science

journal homepage: www.elsevier.com/locate/shpsa

State of the Field

State of the field: Paper tools

Boris Jardine

University of Cambridge, Department of History and Philosophy of Science/Whipple Museum, Free School Lane, CB2 3RH, United Kingdom

ARTICLE INFO

Article history:
Available online 24 August 2017

Keywords:
Paper tools
Sociomateriality
Scientific instruments
History of information

ABSTRACT

Paper occupies a special place in histories of knowledge. It is the substrate of communication, the stuff of archives, the bearer of marks that make worlds. For the early-modern period in particular we now have a wealth of studies of 'paper tools', of the ways in which archives were assembled and put to use, of the making of lists and transcribing of observations, and so on. In other fields, too, attention has turned to the materiality of information. How far is it possible to draw a stable methodology out of the insights of literary and book historians, bibliographers, anthropologists, and those working in media studies? Do these diverse fields in fact refer to the same thing when they talk of paper, its qualities, affordances and limitations? In attempting to answer these questions, the present essay begins in the rich territory of early-modern natural philosophy – but from there opens out to take in recent works in a range of disciplines. Attending to the specific qualities of paper is only possible, I argue, if it is understood that paper can be both transparent and opaque depending on the social world it inhabits and helps to constitute. Paper flickers into and out of view, and it is precisely this quality that constitutes its sociomateriality.

> *Suppose I say to Turing, 'This is the Greek letter sigma', pointing to the sign σ. Then when I say, 'Show me a Greek sigma in this book', he cuts out the sign I showed him and puts it in this book.—Actually these things don't happen.*
>
> Ludwig Wittgenstein, *Lectures on the Foundations of Mathematics*[1]

1. Introduction

I begin with two vignettes from the early years of the Royal Society. First, on May 7th, 1673, a typically garrulous Robert Hooke delivered a short lecture to the Society entitled 'Concerning Arithmetick Instruments'.[2] This was an attack on a group of calculating instruments that had recently been invented and demonstrated by Samuel Morland, Leibniz and others. Earlier in the year, when Hooke had first seen Morland's mechanical calculator, he had written in his diary the terse comment that it was 'Very Silly'.[3] In the lecture he gave full flight to his ire:

> As for ye Arithmeticall instrument which was produced here before this Society. It seemed to me so complicated with wheeles, pinions, cantrights [*sic*], springs, screws, stops & truckles, that I could not conceive it ever to be of any great use (Hooke, 1673)

Why was the great philosopher of mechanism so unimpressed with this mathematical machine? The answer, elaborated in the Royal Society lecture, is as much about Hooke's love of paper as his disdain for unnecessary and expensive instrumentation. 'The best way for Addition and subtraction,' he told his colleagues, 'is by setting down ye numbers on paper and proceeding as in common arithmetic, both these operations being quicker and much more certainly done then by any instrument whatsoever' (Hooke, 1673). The benefits of paper are that

E-mail address: bj210@cam.ac.uk.

[1] See Wittgenstein (1976), p. 20. The Turing referred to is indeed the mathematician and computer pioneer Alan Turing, who was amongst the small group who attended these lectures in 1939. Throughout the lectures Wittgenstein engages with those present when giving examples, but he seems to have been particularly inspired by Turing, who could be counted upon to present a rigorously idealist account of mathematics – the exact position against which Wittgenstein was arguing (see Shanker, 1987). Appropriately enough (given the subject of the present essay and the local flavour of the lectures themselves) the notes of Wittgenstein's students had long circulated in mimeograph before they were collated and edited by Cora Diamond.

[2] The text of this lecture is printed in Birch (1757, pp. 85–87).

[3] Robert Hooke, diary entry for 31 January 1672/3 (Robinson and Adams, 1935, p. 25).

http://dx.doi.org/10.1016/j.shpsa.2017.07.004
0039-3681/

> first ye numbers may be writ down in half ye time they can be set on any instrument, and 2dly they remaining altogether in view may be quickly added or subtracted and the sum or remainder set down, and if there should be any mistake in the first they can be presently run over again (Hooke, 1673)

While this may seem like so much common sense, it also ties Hooke into the long tradition of using everyday materials as aids for arithmetic, and reveals his long-standing obsession with the ways in which paper tools can augment the memory.[4] In modern terms we could say that Hooke was speaking of the 'affordances' of paper.[5]

My second vignette dates from a decade later, *circa* 1683, when Edmund Halley set out to answer an old and seemingly intractable question: how to achieve an accurate measurement of a country's area? Halley had been set the task by John Houghton, who was hoping to include the answer in his *Collection of Letters for the Improvement of Husbandry & Trade*. In 1680 a map had been produced that Halley deemed sufficiently accurate – so he simply cut it up and weighed it, using a circle of known area and of the same paper as a standard. The answer Halley got, for England and Wales, was 38.7 million acres, just a shade over the modern estimate.[6] Halley is thought to have learned the technique of 'cut-and-weigh' from William Petty, but in any case it was a reasonably well known trick. John Wybard, for instance, had given the following account in 1664:

> So likewise might the area of content of any flat superficies or Plane, being drawn upon any moveable and weighable matter or substance, (as Paper most commonly, and so parchment, paist-board, &c.) be discovered or produced accordingly (Wybard, 1664, p. 207).

The strangeness of this proposition was such that Wybard had to remind his readers that paper is indeed a 'materiate thing', even though it be 'such a superficial substance' that is apparently 'not under the dimension of depth or thickness'. Paper 'will shew weight', insisted Wybard, who was thus emboldened to 'dare propound this thing, as one of the most curious and nice operations or experiments to be performed' (Wybard, 1664, p. 207–8).

For Hooke, Halley and Wybard paper was a conspicuous tool of mathematical practice. What is striking in each case is not so much the kind of work done, rather the sudden apprehension of a material that had previously gone unnoticed, or at least unmentioned. And in each case the practical is shot through with social implications. For Hooke, in his argument against the courtier Morland, paper was the substrate of sound mathematical practice. In this he was echoing recent debates over the (dis)merits of mathematical instruments, which could lead practitioners to be 'only doers of tricks, and as it were Juglers' (Hill, 1998). Conversely, for Wybard and Halley, the cut-and-weigh technique was a surprising means to a consequential end: the assessment (by Wybard) of the capacities of barrels, buildings and materials, and (by Halley) the extent of the taxable realm.

Throughout the seventeenth century paper shifted into view and back out again, each new perspective prompted by societal concern. Paper was already transparent – simply the bearer of marks and signs. It was already opaque – a substance to be weighed, looked at under the microscope, traded and discarded. I characterise this condition as *flickering materiality*, and in what follows I argue that it is in fact the central condition of 'paper tools' as a bearers of meaning and of paper as a manipulable substance. In surveying the 'state of the field', I begin with the rich territory of early-modern natural philosophy – but from there I will roam freely, one of my main aims being to take in works that share an interest in paper across time periods and in many disciplines, from Hooke and Halley to Victorian London and twentieth-century Islamabad.

2. Dynamic archives

For early-modern natural inquiry we now have a wealth of information on the precise role of paper in the formation and circulation of natural knowledge. A recent synthetic account is Richard Yeo's *Notebooks, English Virtuosi, and Early Modern Science*, which culminates in a fine description of Hooke's prosthetic archival practice: note-taking as a necessary complement to the more glamorous enhancement of the senses by optical and philosophical instruments (Yeo, 2014, p. 239ff.). The mnemonically paranoid Hooke at one point even calculated the number of facts that a person acquired each day – settling on a number large enough to necessitate what Yeo calls a 'dynamic archive' of moveable slips of colour-coded paper on which new knowledge could be recorded, ordered, sorted and stored. This personal practice was also a model for collective enterprise: gathering up and sorting inscriptions at once permitted *more* material to be collected than could be stored in one person's head; and the rearrangement of that material was itself a process of analysis, even discovery. In this way, note-taking and the sorting of papers was nothing less than the project of navigating between blind empiricism and premature theorizing – the enterprise of the Royal Society itself.

While the empirical project of the early Royal Society might seem like familiar ground, in Yeo's hands it becomes strange again – a place not just of observations, discoveries and inventions, but of scraps of paper, Borgesian lists and indexical machines. In a sense, of course, the latter flow naturally from the former, the solution from the problem. As Ann Blair found for the earlier humanists, the virtuosi simply felt they had 'too much to know' (Blair, 2010) and turned their thoughts and pens to the task of not only shoring up the ruins of their own minds, but also setting in motion a collaborative note-taking exercise that would become the fabric of Solomon's House – a house of index cards (Krajewski, 2011).

It is this mix of quotidian reflection, grand ambition and personal proclivity that begins to add depth to Hooke's thoughts on the use of paper in mathematics. Later in the lecture on arithemetic instruments quoted above Hooke had argued that

> the best *instrument* for squaring & cubing or for extracting the square or Cubick root is by printed tables for that purpose, such as […] Dr. Pell hath lately epitomised and reduced to a lesser volume (Hooke, 1673).

Here Hooke goes far beyond his first statement about the use of pen and paper for calculating. And he equivocates over the nature of an 'instrument': if you must have one, then it ought to be made of paper. John Pell, whose mathematical tables Hooke mentions, plays an important role in Yeo's narrative (Yeo, 2014, p. 125ff). Pell was perhaps the most ambitious and least productive of all the virtuosi. His 1638 *Idea of Mathematicks* (reprinted by

[4] On the tools used for arithmetic – for example, 'a flat polished surface or tablets, strewn with sand, on which figures were inscribed with a stylus' – see Steele (1922, pp. vii–xviii).

[5] The term 'affordances' was first used in this context by James Gibson (1979). As I discuss below, it has been used more recently by Tim Ingold (2007).

[6] See Houghton (1727), vol. 1, pp. 67–70.