Robert Hooke and the visual world of the early Royal Society

Felicity Henderson[1]

Abstract

This article argues that despite individual Fellows' interest in aristic practices, and similarities between a philosophical and a connoisseurial appreciation of art, the Royal Society as an institution may have been wary of image-making as a way of conveying knowledge because of the power of images to stir the passions and sway the intellect. Using Robert Hooke as a case study it explores some of the connections between philosophers and makers in Restoration London. It goes on to suggest that some epistemic images were in fact designed to elicit an emotional response in their viewers, in order to force them to re-evaluate the subject-matter by presenting it in a new and surprising way.

On the first of February 1669, Samuel Pepys took advantage of a cancelled meeting of the Tangier Committee to spend his morning thinking about art. With his colleague and fellow FRS, Thomas Povey, in tow, he proceeded thus:

> [Povey] and I away to Dancres to speak something touching the pictures I am getting him to make for me. And thence he carried me to Mr. Streeters the famous history-painter over the way, whom I have often heard of but did never see him before; and there I found him and Dr. Wren and several virtuosos looking upon the paintings which he is making for the new Theatre at Oxford; and endeed, they look as they would be very fine, and the rest

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> thinks better then those of Rubens in the Banqueting-house at White-hall, but I do not so fully think so – but they will certainly be very noble, and I am mightily pleased to have the fortune to see this man and his work, which is very famous – and he a very civil little man and lame, but lives very handsomely. So thence to my Lord Bellasses and met him within; my business only to see a chimney-piece of Dancre's doing in distemper with egg to keep off the glaring of the light, which I must have done for my room; and endeed it is pretty, but I must confess I do think it is not altogether so beautiful as the oyle pictures; but I will have some of one and some of another. (Pepys 1971, 9:434-5)

Dancre was the landscape painter Hendrick Danckerts (c.1625-1680), for whom Thomas Povey was something of a patron. Pepys's visits on this February morning, and his diary commentary, are indicative of a certain kind of artistic connoisseurship cultivated by some of the key Fellows of the early Royal Society of London. They demonstrate Pepys's interest in artists themselves – he was 'mightily pleased' finally to meet the famous Streater – as well as their works, and also their working methods. The 'distemper', or egg tempera, method of painting had already been the subject of a discussion at a Royal Society meeting, introduced by Povey (Birch 1756-7, 2:84, 107).[2] Pepys, though, seems confident in his own artistic judgement, preferring oils over distemper and championing Rubens over Streater as a painter of allegorical ceiling-pieces (at least in the privacy of his diary). We can also sense, behind Pepys's description, his judgement of the utility or value of the artworks he inspects. Streater's work is judged to be 'fine', and 'noble', the comparison with Rubens giving the new Sheldonian a status similar to Charles I's great Banqueting House. On a smaller scale, his careful choice of paintings for his own home, including an assessment of how the

[2] For more on Povey and his interest in art and artists see Sachiko Kusukawa's article in the present volume.

medium would influence display, is part of a strategic bid to impress his guests.[3] The account, perhaps unconsciously, emphasises the social aspect of Pepys's encounters with art and artists, highlighting the role of Povey as intermediary in the introduction to Streater, and the group of virtuosi together assessing the worth of his paintings.

In this article I want to consider what it meant for Fellows of the Royal Society, such as Pepys and his colleagues Christopher Wren and Thomas Povey, to have such close associations with Restoration London's artists and craftsmen.[4] I am most interested in the influence that these associations might have had on the methodology of science in the period up to around 1700, when the Society was dominated by men such as Robert Boyle, Robert Moray, John Wilkins, William Petty, John Evelyn, William Brouncker, and most importantly for my purposes, Robert Hooke.[5] Most early Fellows were members of the gentry or aristocracy, but as an institution the Royal Society relied on the activities and expertise of a wider penumbra of individuals who played a supporting role but were not themselves identified as new philosophers.[6] By investigating how these outsiders contributed to specific projects and experiments, we gain a clearer understanding of how the social and cultural context of Restoration London shaped the development of science in England. In the second part of the article I argue that although the worlds of art and science were interconnected, Royal Society Fellows may have been wary of relying too heavily on images to communicate their ideas because of a longstanding belief that images had the power to sway the reason by appealing to the passions. Despite this, I suggest, some epistemic images seem designed to take advantage of precisely this appeal. Like their response to the idea that rhetorical

[3] For Pepys's use of his book collections in a similar way see Loveman 2015, esp. chapter 9, 'Libraries and closets'.
[4] For other Fellows who were proficient draughtsmen themselves, or who engaged others to produce images for them, see Sachiko Kusukawa's article in the present volume.
[5] I am indebted to a number of scholars who have already written on Hooke and art, in particular Matthew Hunter, Meghan C. Doherty and John T. Harwood, whose work is cited below.
[6] On the social composition of the early Royal Society see Hunter 1982.

ornamentation in speech and written texts should be avoided, I argue that their attitude to images was not straightforward.

Robert Hooke's scientific methodology: seeing and knowing

Robert Hooke is a useful figure to study when asking questions about the relationship between the Royal Society and other worlds in Restoration London. While noblemen such as Robert Boyle and William Brouncker, clergymen such as John Wilkins, and courtiers such as Petty, Evelyn and Moray had access to the court and nobility, their circles of associates were (to a greater or lesser extent) confined to those spheres. Hooke, on the other hand, like his colleague Christopher Wren and like Pepys, Povey, and many other less active Royal Society Fellows, associated with a much wider circle of acquaintance. Hooke's own mechanical skill and his interest in developing experimental apparatus, together with his increasing involvement in architectural and civic projects after the Fire of 1666, meant that he was in almost daily contact with instrument makers, builders and other tradesmen, guild officials, and a great swathe of London's coffee-drinking, book-browsing, news-exchanging middling sorts. This in itself did not make him unusual among his Royal Society colleagues, but in combination with his central position in the Society as one of the leading experimenters and theorists of the period, it made him unique. We are also extremely lucky in that, like his colleagues Pepys and Evelyn, he was a prolific diary-writer, and so we have an almost daily record of his movements throughout the 1670s and again in the late 1680s-early 1690s.

This article, then, will take Hooke and his activities as its focus for an exploration of associations between experimental philosophers and artists or craftsmen in Restoration London. In doing this, I want to foreground an aspect of Hooke's methodology, or philosophy of experimentation, that has not previously received much attention from scholars. His 'General Scheme, or Idea of the present state of natural philosophy', published in his *Posthumous Works* by his first editor, Richard Waller,

explains what Hooke sees as the best way for an experimental philosopher to proceed in the investigation of nature (Hooke 1705). In particular, he wants his readers to understand how to frame and answer research questions in a methodical way. His scope is broad, ranging across the whole of the natural world and, as we shall see below, also encompassing much human activity. One of the points to which he frequently returns is the need to notice, and record, every detail that might be significant. This has two aspects. First, he warns against neglecting common and seemingly unimportant things, something that Francis Bacon had also stressed.[7] Useful knowledge, Hooke warns, might be found 'in all Estates and Conditions of Men':

> even out of the most vile and seemingly most foolish and trivial things, and of those which are most common, and therefore pass without regard, because usual, may be collected things of most excellent Use; and therefore, nothing in this Design [ie. list of research areas] is to be look'd on with the Eye of the Vulgar, and with Prejudice, according to the Esteem it has obtain'd in the World with the Generality of Men, who generally judge or esteem of things only for the immediate Pleasure or Profit they afford, and look no further.

The philosopher's eye sees the world radically differently from the vulgar person's eye, which looks at the surface of things and judges them according to their capacity to provide 'immediate Pleasure or Profit' (Hooke 1705, 27). The philosopher needs to set aside any preconceived ideas about the value of common things, and look at them with fresh eyes.

The importance of seeing things differently reappears later in Hooke's methodology, in his outline of the second requirement for recording significant details of an experiment or observation: the need to note down all the 'circumstances'.

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[7] See, for example, Bacon 2000, 64ff; Boyle [1663] 1999, 209-10. On Hooke's Baconianism more broadly see Anstey 2014, Oldroyd 1987.

> In the making of all kind of Observations or Experiments there ought to be a huge deal of Circumspection, to take notice of every the least perceivable Circumstance that seems to be significant either in the promoting or hindering, or any ways influencing the Effect. And to this end, as I mentioned before, it were very desirable that both Observations and Experiments should be divers times repeated, and that at several Seasons and with several Circumstances, both of the Mind and of Persons, Time, Place, Instruments and Materials: For all these do very much contribute to the Discovery of Circumstances. (Hooke 1705, 61-2)[8]

It is interesting that Hooke includes 'the Mind' among the circumstances he recommends varying in repeated experiments, alongside the more usual 'Persons, Time, Place' and so on. Although it is not entirely clear what he meant by this, he does go on to suggest that the philosopher's mental attitude to the experiment was crucial. Even if he has made an observation, or seen the outcome of a particular procedure, many times, Hooke argued, he should endeavour to look at them as though they were 'the greatest Rarity'. Indeed, the observer should attempt to go even further: he should 'imagine himself a Person of some other Country or Calling, that he had never heard of, or seen any thing of the like before'. Strangers, Hooke argued, were much better at taking notice of details that people familiar with places or procedures would not bother to mention.

> I find it very common for Tradesmen, or such as have been much versed about any thing, to give the worst kind of Description of it for this purpose; and one that is altogether ignorant and a Stranger to it, if he be curious and inquisitive, to make the most perfect and full Description of it.

[8] Hooke was writing here about the initial notes of an experiment or observation, which he intended should be recorded in a larger book of experimental results for the use of the experimenter himself, rather than as a final communication of his results. For more on this, see Hooke 1705, 42, 63.

Similarly, travellers to foreign countries were capable of giving better accounts of places than native people, since travellers 'take notice of all the things which because of their Newness seem strange', whereas natives, who are accustomed to such things, omit them. At the same time, of course, those that were natives or experts had a much better grasp of the material facts and were able to answer questions more satisfactorily. Therefore, Hooke suggests,

> every Experimenter and Observator . . . should indeavour to make himself as knowing and as much vers'd in any thing he is to describe, and to suppose himself as ignorant and unacquainted as if wholly a Stranger: For as the one will make him inquisitive, so the other will inable him to solve his Doubts. (Hooke 1705, 61)

Earlier in his 'General scheme' Hooke had recommended repeating experiments in the presence of someone who was unfamiliar with that particular procedure, 'though ingenious and inquisitive in other Physical Searches', for the same reason: a bystander might 'take notice of many Particulars which are in themselves very observable, but were and would still have been neglected because of their being obvious' and because the experimenter was accustomed to seeing them (Hooke 1705, 28). Here, however, he goes one step further and recommends that the ideal experimenter be both expert and neophyte at the same time – or at least, imagine himself to be.

This peculiarly dual character advised for the experimenter is not, to my knowledge, taken up elsewhere and we need not imagine Hooke or any of his colleagues taking this particularly seriously. It does, however, suggest some possible concerns over the notion of expertise in the early scientific community. Clearly, Hooke felt that it was possible to be too familiar with a subject to be able to see the details, or to communicate it effectively for the purposes of scientific research. The ideal arrangement outlined here was one where an expert in one field collaborated with an expert in another field, and Hooke did put this into practice in his scientific research, at least to a certain extent. The

first part of this article will outline some of Hooke's observations of, and discussions or collaborations with, artists and craftsmen. Through describing these interactions I hope to demonstrate the breadth of possible connections between Fellows of the Royal Society and London's artistic community and invite future researchers to probe individual connections more deeply. This section builds on work done by Matthew Hunter, Meghan Doherty and Rob Iliffe on the significance of Hooke's relations with artists and artisans for his natural philosophy and his own drawing practice (Iliffe 1995; Doherty 2012; Hunter 2013). I link these connections with some of the methodological arguments Hooke made in his 'General scheme', which promoted (though not explicitly) a strand of research supported by the Royal Society as an institution in its early years, the 'history of trades' programme. In Hooke's mind, it was vitally important for experimenters to have access to the existing knowledge of the productions of art currently possessed by men in all manner of trades and occupations. As shall be discussed further below, this knowledge of art could be used to discover the secrets of nature.

As we have seen, though, Hooke suggests that the process of scientific discovery could be hampered by too great a familiarity with the subject. Science required its practitioners to enter the world anew and see everything as though for the first time, like the young woman who, in Boyle's account, had been blind since birth and had had her cataracts removed. Boyle used the anecdote to support a point both theological and philosophical:

> The bare prospect of this magnificent Fabrick of the Universe, furnished and adorned with such strange variety of curious and usefull Creatures, would, suffice to transport us both with Wonder and Joy, if their Commonnesse did not hinder their Operations. (Boyle [1663] 1999, 200)

I think that Hooke and his Royal Society colleagues saw it as part of science's task to make the familiar unfamiliar, for themselves and also for their (mostly unimpressed)

contemporaries, in order to see the ordinary things of the natural world with the kind of 'Wonder and Joy' suggested by Boyle. The second part of the article will explore how this was achieved, concentrating specifically on images. Here I would like to suggest that once again the Fellows had to reconcile opposing positions. In this case, a wariness about the potential for images to disturb and unduly influence the mind had to be balanced against the beneficial power images have to destabilise world-views and make things unfamiliar.

Art, craft, and natural knowledge

In an undated but seemingly early lecture about experimental method, Hooke argued that the natural philosopher should 'Indeavour to be knowing and versed in all the various ways of examining and trying of matter'.[9] For him, this means learning trades.

> that Is he should Indeauour to be conuersan[t] with all kinds of trades men to learne their operations and to practise their manner of working in præparing refining, curing Dressing Scowring Dying tanning working fashioning hardning, softning, cutting boaring filing turning beating grinding boyling melting clarifying drying baking burning nealing twisting spinning weauing, glewing. powdring compounding separating clarifying fermenting Distilling Dessoluing coagulating, founding, casting, calcining, præcipitating & a multitude of other operations[10]

Even for someone as fond of lists as Hooke, this tumult of activity seems excessive; but it demonstrates the scale of industry in and around London and Hooke's sense of himself at the centre of a thriving commercial hub. In addition to processes, he also required his natural philosopher to pay attention to the raw materials and tools used by tradesmen, and in all this he should not rely on the 'words or reports of some cosening workmen

[9] For the context of the lecture see Oldroyd 1987, 159.
[10] Royal Society Archives Cl.P/20/50a, f. 8^{r}; printed in Oldroyd 1987, 156-7.

but he ought either to perform the operation himself or with much circumspection and diligence to oversee and examine the performance of it by the workmen.' (Oldroyd 1987, 157). I will return to what this meant for Hooke himself in practise below. In his edition of Hooke's lecture D. R. Oldroyd was correct to point out that it arose in the context of Hooke's Gresham College lectureship, which specified a focus on the history of trades, and that this may have caused him to place particular emphasis on the significance of trade knowledge for natural philosophy (Oldroyd 1987, 159). This emphasis is consistent throughout Hooke's writings though, and in his 'General Scheme' (seemingly composed slightly later than the lecture quoted above) he provided a list of trades ripe for investigation. His list of 'such [tradesmen] as are conversant about the Mineral, Vegetable, and Animal Substances' included artists and craftsmen of all kinds, and was organised by the materials with which tradesmen worked.[11] Painters, limners, and 'Picture Drawers' appear in a section devoted to those who worked with 'Earths and Clays', alongside potters, tobacco pipe makers, spectacle makers and other glass workers, makers of counterfeit pearl and precious stones, colour-grinders, enamellers, varnishers, and 'Makers of Baby Heads'. Engravers and etchers appear elsewhere, among other workers in copper and brass, including makers of clocks, watches and mathematical instruments (Hooke 1705, 24, 25).[12] Hooke suggests that there might be two reasons for compiling these descriptions of trades.

> In the writing of all which Histories there may be two things design'd, either a Description of the things themselves, whereby Inquisitive Persons that are ignorant of them, may come to a more perfect Knowledge of them; in order to some other Design as for Curiosity, or Discourse, or Profit, and Gain, or the like: Or such a Description of them as is only in order to the Use of Philosophical Inquiry, for the Invention of Causes, and for the finding out

[11] Compare Hooke's categories with those used by John Evelyn in his own list of trades (Hunter 1995, 75ff; Kusukawa, present volume).
[12] 'Baby heads' were dolls' heads.

> the ways and means Nature uses, and the Laws by which she is restrain'd in producing divers Effects. (Hooke 1705, 26)

By reading such discourses, 'inquisitive persons' might furnish themselves with material for cogitation and conversation, which are grouped here alongside 'profit, and gain'. And although his own design is for philosophical enquiry, he suggests that those with the former intention would 'find much to satisfy their Desires' (Hooke 1705, 26-7). Is this a gesture towards a more connoisseurial appreciation of the mechanical arts? Perhaps not when it came to processes such as the making of salt at a saltern in Hampshire.[13] But a desire to know more about the processes of production, and the ability to converse about them knowledgeably with like-minded men, together with an appreciation of the economic aspects (if not an actual desire for profit or gain), could equally describe Pepys's attitude to art, as illustrated above. It seems that the traits of connoisseurship and the methods of philosophical inquiry were not dissimilar, and could both be applied to many (if not all) trade practices.[14] John Evelyn's *Numismata* includes a chapter of 'Instructions how to Collect and Procure such *Medals* as are *Antique* and *Rare*, and to Distinguish the *True* from the *False*, for the Prevention of *Frauds* and *Impostures*' (Evelyn 1697, 198, italics reversed). The instructions emphasise what are seen as valuable qualities in coins and medals (beauty, 'Excellency of the Design and Workmanship', a well-judged composition, etc), giving collectors some idea of how to judge the relative worth of specimens; Evelyn also mentions some of the ways in which fraudulent coins can be made to look genuine (Evelyn 1697, 200, 213). A knowledge of materials and techniques is one of the skills that a collector must develop in order to protect himself from frauds and impostures.[15] The following section will explore what

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[13] See Hooke's description and illustration, Royal Society Archives Cl.P/20/40.
[14] Jonathan Richardson later linked the two activities, advising that ''Tis as necessary to a *Connoisseur* as to a Philosopher, or Divine to be a good Logician' (Richardson 1719, 203).
[15] Compare with William Sanderson's advice on distinguishing an original painting from a copy (Sanderson 1658, 16-17), and Hooke's belief that natural philosophers should make themselves aware of methods for imitating or counterfeiting things (Oldroyd 1987, 157).

this interest in trades might have meant in practice by discussing Hooke's relations with a range of makers in Restoration London.

Part I: Hooke's associations with London's artists and craftsmen

According to his own autobiography, Hooke experimented in his childhood with mechanical devices, and 'had also a great fancy for drawing', teaching himself by imitating prints. Apparently he succeeded so well at this that 'Mr. *Hoskins* (Son to the famous *Hoskins Cowpers* Master) much admired' his productions (Hooke 1705, ii).[16] Thus his relationship with London artists began at an early age. At some point in his early teenage years he worked as an assistant to Sir Peter Lely, before moving on to Westminster School and then Oxford. Hooke's diary entries, made much later than this, during the most active period of his working life, demonstrate the kinds of associations he had with London's artists and art collectors.[17] In particular, he was in regular contact with painters and miniaturists, and collectors or vendors of prints and architectural books. He kept in contact with Sir Peter Lely, but he also recorded his meetings with many of London's other artists, including the engravers and etchers William Faithorne the elder, David Loggan, Robert White, Wenceslaus Hollar, Francis Lamb, Edward Le Davis and Walter Dolle, the miniaturist Matthew Snelling, sculptors Caius Cibber and Edward Pearce and painters Robert Streater, Abraham Hondius, John Baptist Gaspars, John Riley, Mary Beale, Mary Moore, Thomas Wyck and Remigius (Remy) van Leemput.

[16] This was John Hoskins the younger (b. c. 1617), son of miniaturist John Hoskins (c. 1590-1665), who had brought up his nephews Samuel and Alexander Cooper, both also miniaturists (Murdoch 2004).

[17] Hooke's diary entries are extant for the periods March 1672 to May 1683, published in Hooke 1935b, and Henderson 2007; and November 1688 to August 1693 (with a break between March 1690 and December 1692), published in Hooke 1935a. Quotations from the 1935 printed sources have been emended, in many cases silently, after comparison with the original manuscript texts of the Diary, now London Metropolitan Archives CLC/495/MS01758 (printed in Hooke 1935b) and British Library MS Sloane 4024 (printed in Hooke 1935a).

These meetings were sometimes as a result of Hooke's various employments, and sometimes in the course of his more personal pursuits – although we should be careful about demarcating too strictly between Hooke's public and private lives as the two were closely entangled. Although Hooke's diary is not primarily a record of his scientific work, nevertheless it gives an insight into the kinds of thought processes, experiences and conversations that underpinned some of his scientific work.

Perhaps above all else, Hooke's terse diary entries emphasise the significance of 'seeing', and the vast variety of sights (and sites) Restoration London afforded. The verb 'saw' appears more than any other in the diary, and while some of the things Hooke saw were related to his surveying or architectural work, many more were not.[18] Among these sights were images, and artists in the process of creating them. Both sights were worthy of noting in the diary. So, for example, in December 1673 Hooke was at fellow surveyor John Oliver's and 'saw him paint glasse'. Oliver was a glass-painter by trade prior to his appointment as a surveyor of London after the fire in 1666.[19] In this, as in other cases, Hooke recorded his interest in both the process or materials of art, and the artist. He saw a further example of painting on glass the following year, in the company of his friend and Royal Society colleague Sir John Hoskyns.

> To Mr Hoskins. Saw a curious way of painting on the backside of a looking glasse plate at Mr Bartue chamber in pump court 2 pair of stairs high. It was done by one Monsieur Tues lying at the Smiths by the green dragon in the Pallmall. We could not find him nor Mr Wind. nor Monsieur Van Aerst.[20]

The fact that Hooke and Hoskyns tried to locate 'Monseiur Tues', and that Hooke noted his lodgings and the location of the painting in such detail, suggests that he was keen to find out more about the 'curious' method. He was not always quite as complimentary.

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[18] The word 'saw' appears 578 times in the diary; 'told' appears 501 times, 'read' 397 times.
[19] 9 December 1673 (Hooke 1935b, 74). For Oliver see Cust 2008.
[20] 19 July 1674 (Hooke 1935b, 113); like Hooke, I have been unable to track these gentlemen down.

When Walter Dolle showed him a plate Dolle had made using a mezzotint process, Hooke initially thought it had been executed using Sir Christopher Wren's method, 'but it proved to be done by squeezing a file on it with a presse'. Hooke commented disparagingly 'I suppose it may be much better done by Sir Christopher Wrens powder'.[21] Again, attention to method seems to have warranted noting this in the diary, as the outcome was not deemed (by Hooke) to be particularly successful.

On other occasions Hooke was more positive. He seems to have been particularly impressed by the work of Thomas Wyck, commenting in December 1674 'At Wikes, Saw pictures of chymist very rare', and on another occasion while visiting David Loggan he 'Saw Waickes painting and another of a goat very Rare', and again at Loggan's 'Saw Wickes Landscape'.[22] Loggan acted as an art agent for English gentry, so these may have been destined for one of his clients (Tyack 2004). Hooke saw 'rare pictures' at 'Mr Genues' house, which he visited during a stormy day in December 1675.[23] He seems to have been less interested in the 'pictures' he saw at 'Cades': this was probably John Cade, bookseller 'at the sign of the Globe in Cornhill' near the Royal Exchange, one of the booksellers for whom Richard Gething's book of calligraphy *Gethings Redivivus: or the pens master-piece restored* (London, 1664) was printed. It is unclear whether these pictures were Cade's private collection or shop stock, but if Hooke's later note 'At Picture shop Globe exchange' also refers to Cade's shop then we can assume that the latter was the case. Hooke certainly records buying a map of England from Cade in April 1678.[24] While this series of records demonstrates Hooke's general interest in seeing art

[21] 3 April 1674 (Hooke 1935b, 95); for another method of printing invented by Wren see the Royal Society minutes for 2 December 1669 (Birch 1756-7, 2:409). Wren's mezzotint method has been discussed in Griffiths 1990 and Godfrey 1991. For Dolle see Griffiths 2004a.
[22] 8 December 1674; 16 October 1675; 6 May 1676 (Hooke 1935b, 134, 188, 230). It is possible that the latter two references are to works by Thomas Wyck's son Jan, although Hooke would normally make this distinction clear.
[23] 27 December 1675 (Hooke 1935b, 204). Probably either John Genew, Common Councilman for Dowgate Ward (1678-82), or his brother William (Woodhead 1966).
[24] 8 October 1673; 20 April 1678; also 6 and 22 May 1678 (Hooke 1935b, 64, 354, 357, 359). Cade also supplied Hooke with stationery including paper, pasteboard and ink.

among the other sights of London, the lack of specific information suggests that either he was not interested in a connoisseurial appreciation of the pictures he saw, or that the diary was not the place to express this.

Despite not rhapsodising in his diary about the pictures he saw, Hooke was himself a collector. He is well-known as a frequenter of London bookshops, and his own library included a number of books relating to the visual arts (Doherty 2012, 217-8).[25] These were supplemented by books borrowed from elsewhere: so, for example, he took advantage of the Arundel Library and in April 1673 borrowed '3 volumes of Vasari of the Lives of the Painters, Cæsari Ripa of Iconologia, Rubens Life etc'.[26] It was not until January 1677 that these (and other) volumes were returned to the library, at the instigation of the Royal Society's president, Viscount Brouncker.[27] Hooke also collected prints. In 1675, he purchased from Henry Oldenburg Jean Marot's *Recueil des plans, profils et élévations des plusieurs palais, chasteaux, églises, sépultures, grotes et hostels bâtis dans Paris et aux environs* ([s.n.], [s.n.]). In June 1676, he bought a collection of '90 pages of Bachinall grotescues, Ceelings, gates, Compartments and Sheilds, besides the Pallace of Richeleu and the church of the Sorbon at Large'.[28] Anthony Geraghty has pointed out that this collection was part of the estate of Wren's colleague Edward Woodroofe, and clearly they relate to Hooke's architectural work (Geraghty 2004, 116). Listing his prints in 1677, Hooke mentioned several Italian subjects including 'Piazza del populo', 'Berninis St Pieter', and 'Fornesys Jesuits church at Rome', as well as further French buildings, 'eighteen chimneys and altars', 'Fifteen of Perill's prospects' and '109 views of Israells'.[29] These last two collections were the work of French engravers Gabriel

[25] For a searchable online database of Hooke's library see www.hookesbooks.com.
[26] 9 April 1673 (Hooke 1935b, 38). The titles mentioned were: Vasari 1568; Cesare Ripa, *Iconologia* (the Arundel Library contained two Italian editions published in Milan (1602) and Padua (1611)); 'Rubens Life' is unidentified, possibly Bellori 1672. I am indebted to Alexander Marr for the final suggestion.
[27] 26 January 1677 (Hooke 1935b, 270); the list of books returned included Verdizotti 1622 and Rubens 1622 (a title that also appears in Hooke's posthumous library catalogue).
[28] 3 June 1676 (Hooke 1935b, 235).
[29] 10 June 1677 (Hooke 1935b, 294-5).

Perelle and Israel Silvestre, and Hooke seems to have bought them from the joiner Roger Davies (Geraghty 2004, 116). Davies had recently returned from France and Hooke also bought some French art books from him including Abraham Bosse's engravings and Claude Boutet's manual on miniature-painting.[30] In this case, Davies was possibly acting under Hooke's instructions and had brought back books that were harder to find in London than in Paris. On another occasion Hooke bought a 'Snow peice' from Christopher Cox, paying £3.[31] Cox was an instrument-maker who supplied Hooke with lenses and other apparatus, but he was also a friend, and as late as July 1693 Hooke recorded 'at Mr Coxes. his father hearty 95 years old Saw many fine pictures'.[32] While, again, there are no details about what made the pictures 'fine', clearly Hooke did have an appreciation of art beyond simply prints that he might draw on in his architectural work.[33] This is presumably what prompted the sculptor Caius Cibber to give Hooke 'a picture of Toby and his fish'.[34]

Hooke also noted occasions when artists he visited were making (or had made) portraits of people Hooke knew. So, for example, in October 1675 he was at David Loggan's studio, and recorded that Loggan was 'Drawing Sir Robert Reddings picture like, also Dr Bathursts and Dr Wallis's'.[35] Reading, Dr Ralph Bathurst and Dr John Wallis were all Fellows of the Royal Society, and Reading was a fairly regular companion of Hooke's in coffeehouses and elsewhere.[36] Portraiture also took place outside the artist's studio. In April 1676 Hooke visited his friend the physician and Royal Society Fellow Daniel Whistler, where he found Loggan drawing Whistler's picture. The three men repaired to 'Tarts Coffee house', and Loggan gave Hooke 'Dr Alestreys picture': this was

[30] 17 May 1677 (Hooke 1935b, 291).
[31] 16 and 19 March 1675 (Hooke 1935b, 153).
[32] 24 July 1693 (Hooke 1935a, 261).
[33] Further light is shed on this by Matthew C. Hunter in Hunter 2010.
[34] 16 September 1673 (Hooke 1935b, 60).
[35] 16 October 1675 (Hooke 1935b, 188).
[36] References to Reading are scattered through Hooke's diary; see esp. 11 February 1676 (Hooke 1935b, 217) for Reading as part of a group planning to bid for the construction of a mole in Tangier.

the Church of England clergyman and regius professor of divinity Richard Allestree, a prominent member of Hooke's former college, Christ Church.[37] These and other encounters demonstrate that portraits of Royal Society Fellows (and other worthies) had a personal significance for members of the philosophical community which presumably underpinned the increasing prestige they were gathering in an institutional setting during this period, as described by Sachiko Kusukawa in her article in the present volume. Like the copies of his printed books that Hooke distributed to his close circle of friends, and the rings or gloves he often received at funerals, portraits could be presented as tokens of esteem. In the case of Loggan, the gift of a portrait of Richard Allestree to Hooke was part of a complex relationship between the two men that spanned business and personal interests. When the physician, anatomist and Fellow of the Royal Society Sir Edmund King gave Hooke a mezzotint portrait of himself in February 1689, it was a more straightforward signifier of personal friendship and philosophical collaboration.[38]

As Hooke's collection of architectural prints demonstrates, images had an educational role. Hooke occasionally set his assistant Henry (Harry) Hunt the task of copying images, presumably acting as drawing tutor himself. He noted occasions when he 'Borrowd pictures for Harry', and when Hunt was given commissions such as the task of copying pictures for Ralph Montagu, first Duke of Montagu, whose palatial mansion in Bloomsbury Hooke was building.[39] Hooke may also have encouraged Hunt to experiment with colour and technique, as he occasionally recorded the results. In April 1674 he noted 'Harry found that painting with Lake on Red Lead made a most orientall colour for flowers', and in June that year he recorded Harry's trial of painting on silver.[40]

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[37] 12 April 1676 (Hooke 1935b, 225).
[38] For King see Martensen 2004. This was presumably the mezzotint by Robert Williams after Sir Peter Lely.
[39] 13 October 1673; 3 April 1675 (Hooke 1935b, 65, 157).
[40] 4 April 1674; 6 June 1674 (Hooke 1935b, 95, 106).

Hunt grew to be an extremely accomplished artist, often preparing images for the Royal Society, as Sachiko Kusukawa has discussed elsewhere (Kusukawa 2011).

Hooke's expertise, and his propensity for experiment and innovation, was also shared with a much wider community of artists and craftsmen. He worked with engravers on the illustrations for his own books, and those of others, and he was deeply interested in the processes of engraving and printmaking. It is unfortunate that his most visually impressive work, *Micrographia* (London, 1665) was completed before the diary begins, so we cannot track the progress of the plates. The diary, though, shows Hooke giving illustrations for his later works either directly to engravers, or via John Martin, the Royal Society's official printer. In July 1674 William Faithorne seems to have been given plates for Hooke's first published Cutlerian lecture, *An attempt to prove the motion of the Earth* (London, 1674). Hooke noted 'Saw Mr Faithorn had traced figure with Black Lead on white wax on the plate'; he saw a proof copy on 1 August and spent the following morning adding the lettering, then the next day returned the plate to Martin's shop for Faithorn to collect.[41] On 18 August he 'Drew Designe for second plate', probably again of the *Attempt to prove the motion of the earth*.[42] Several days later he seems to have given a plate to Edward Le Davis to engrave, and he was with Le Davis again soon afterwards.[43]

This was a busy year for Hooke as he carried on preparing the Cutlerian lectures for print. In December he wrote 'Harry finish plate but grumbling. Put plates to Lamb to Letter.' and the following day 'to Martins Lamb had finisht plate. Book compleat about Hevelius'.[44] Sure enough, two days later he 'took of Martin 6 Guilt 6 plaine' copies of his *Animadversions on the first part of the Machina Coelestis of . . . J. Hevelius* (London, 1674)

[41] 18 July, 1-3 August 1674 (Hooke 1935b, 113, 115).
[42] 18 August 1674 (Hooke 1935b, 118); the book contains five plates in total.
[43] On 24 August 1674 Hooke has written, but then crossed through, 'with Daueys gaue him plate to graue. at Mr Martins with him' (London Metropolitan Archives, CLC/495/MS01758). For Le Davis see Griffiths 2004b.
[44] 9 and 10 December 1674 (Hooke 1935b, 134).

and presented gilt-edged copies to Lord Brounker, Sir George Ent and Sir Christopher Wren. On this occasion, the engraver Francis Lamb had completed, by adding the lettering to the plate, what Hunt had (seemingly begrudgingly) begun. On another occasion William Sherwin engraved plates for Hooke.[45] Having close associates such as Hunt do some of this work, and keeping a close eye on proceedings, must have helped Hooke to maintain control over the quality of his plates, and possibly kept costs down.

Hooke's own technical skill may also have come into play. He was genuinely interested in innovative printing processes, and mentions several inventions in his diary. Some of these are (seemingly) his own ideas, such as the note-to-self 'Etching vpon horne with a needle. and præsently printing off with a Rowlpresse.'[46] He may have shared this particular thought, since the following month he recorded that William Leybourn had told him 'of Dr Wilkins using of horn for graving when his *Swift Messenger* was printed.'[47] John Wilkins's *Mercury, or the secret and swift messenger* was printed in London in 1641; Leybourn, who worked with Hooke as a surveyor after the fire of 1666, had himself been a bookseller and printer in the 1650s and so knew the trade. Hooke also had conversations with John Ogilby and Joseph Moxon in the early 1670s about techniques for printing maps. Ogilby was at this point engaged in various cartographical projects including his ongoing series of world atlases (*Asia, the first part* appeared in 1673), the map of London after the fire, and his road-atlas *Britannia* (London, 1675). In October 1673 Hooke met Ogilby at Garraway's coffee-house and showed him 'the way of Letters for marking his map and also the way of shadowing'.[48] Early in 1675 Hooke told Ogilby 'my fantcy about letters graved on metall', and Ogilby seems to have pursued this as a week later Hooke recorded 'At the carvers saw clock frame and marginall metall for

[45] 27 June 1676, undated entry for late August 1676 (Hooke 1935b, 238, 247-8); probably both referring to plates for Hooke 1677.
[46] Note, *circa* 4 December 1672 (London Metropolitan Archives, CLC/495/MS01758).
[47] 3 January 1673 (Hooke 1935b, 19).
[48] 14 October 1673 (Hooke 1935b, 65). Meghan Doherty has found this piece of advice particularly illuminating given the significance of shadowing in Hooke's illustrations for *Micrographia* (Doherty 2012, 218).

Ogylbys Letters and borders.'[49] This was apparently a method of copperplate engraving intended to simplify or speed up the process of adding lettering to maps. Hooke 'discoursd about cutting borders letters &c for common press in copper' shortly afterwards with the printer and globe-maker Joseph Moxon.[50] Moxon had produced the complicated type required for John Wilkins's *Essay towards a real character* (London, 1668), and his knowledge of all the practical aspects of printing found an outlet in his later publication *Mechanick Exercises. Or, the doctrine of handy-works. Applied to the art of printing* (London, 1683) (Bryden 2004). His expertise would have been useful to Hooke, and indeed the two met fairly regularly and discussed various things pertaining to map-making, mathematics and metallurgy.[51] Hooke also drew inspiration from his early conversations with instrument-maker Thomas Tompion, whom he seems first to have met in June 1674. Later that month Hooke noted 'At Tompions. Invented the way of printing with the common press pictures made with Pinns. An Invention of Great use. Of this more elswhere'.[52] As far as we know, he never developed this idea further in writing, but shortly afterwards Hooke did tell his Royal Society colleague Sir John Hoskins his 'way of Pictures by pin wire'.[53] Even though Hooke never explains the details of his ideas, it is clear that all these innovations have the common intention of enabling images or text to be printed more quickly and cheaply.

Hooke was by no means the only member of his group of associates to be experimenting in this way. He kept in intermittent contact with William Sherwin, a leading engraver who, as we have seen, occasionally produced plates for Hooke's publications. Sherwin is also associated with the new process of mezzotint, producing in

[49] 22 and 29 January 1675 (Hooke 1935b, 143, 144).
[50] 11 February 1675 (Hooke 1935b, 146); Robinson and Adams transcribed 'common' as 'roman'.
[51] See for example, 29 May 1674, 3 October 1674 (Hooke 1935b, 105, 124). On 31 December 1677 Hooke recorded 'Calld on Moxon, he read me his first monthly exercise of smithery and præface in order to license'; he bought a copy of the book on 7 January for sixpence (Hooke 1935b, 337-8, 339).
[52] 29 June 1674 (Hooke 1935b, 109-110).
[53] 10 July 1674 (Hooke 1935b, 112).

1669 a portrait of Charles II which is the first datable English example of the method.[54] However, Hooke was apparently more interested in a different invention of Sherwin's. In 1676 Sherwin patented a new method of 'printing of broad callicoe & Scotish cloath with a double necked rowling prese . . . the only true way of East India printing & stayning such kind of goods' (Woodcroft 1854, 38). In August that year Hooke 'Saw sherwins new inuented way of staining callico' when dropping off the last plate of *Lampas* for Sherwin to engrave.[55] Printing on cloth was new in England, but Sherwin was not the only person working on the process and Hooke had discussed methods of staining calico with his associates Thomas Hewk and Edmund Wylde FRS earlier in the year.[56] He had also made some trials himself.[57] In 1672 he recorded 'Mr Barret shewd me his flowerd printed cloth'.[58] This was Patrick Barrett, a member of the Blacksmiths' Company whose inventory, compiled after his death in 1687, shows that he was printing onto calico and other cloth.[59] A brief notice in the *London Gazette* describes Barrett's 'large Collection of Copper Plates, engraven with great variety of Statues and other curious Ornaments for Hangings, Curtains, &c. also variety of Landskips and small Figures for Shashes', advertised for sale by Mrs Barrett after her husband's death (*London Gazette* 1688, 2380:2).[60] In August 1673 Hooke 'Saw new stuff at Barrets and new printers Black'. Hooke actively collaborated with Barrett in experiments with printing on cloth. In March 1674 he wrote 'at Barrets. Made tryall of Golding flowerd Shift which succeeded'.[61] It is possible that this line of experiment had been suggested to Hooke by the visit to the Royal Society by one 'Mr. Elers, a foreigner', who had showed

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[54] For Sherwin see Griffiths 2004c.
[55] 28 August 1676 (Hooke 1935b, 247; Robinson and Adams transcribed 'sherwins' as 'Sheranis').
[56] 20 March 1676 (Hooke 1935b, 221; Robinson and Adams transcribed 'Hewk' as 'Haak').
[57] For Hooke's experiments see Birch 1756-7, 2:396, 399, 414 (meetings of 21 and 28 October 1669, and 13 January 1670).
[58] 17 December 1672 (Hooke 1935b, 16).
[59] See Barrett's inventory, The National Archives PROB 4/17174; and his will, The National Archives PROB 11/387/58.
[60] 10 September 1688.
[61] 11 March 1674 (Hooke 1935b, 91).

'several patterns of stuff, which by the press had received the likeness of cloth of gold and silver'; Elers claimed that 'a certain German' intended to get a patent to make this in England.[62] As late as 1679 Hooke was still discussing cloth printing with Barrett: 'At Barrets, with him to Garways [ie. Garraway's coffeehouse]. Discoursd to him the way of staining Sattin with Lead moulds and copper plates.'[63]

Barrett's and Sherwin's experiments with printing designs onto cloth must have been particularly fascinating for Hooke, given his interests in dyes and printing processes, and his expertise as a draughtsman. However Hooke recorded many other conversations in coffeehouses and elsewhere with people who were keepers of trade secrets or innovators in fields related to manufacturing. He shared the Royal Society's interest in dyeing and colours; he also discussed methods of transferring painted or printed images, staining marble, glass-painting, making marbled paper, enamelling tiles; and recipes for varnish, and 'a paint not to be washt from the face with wett' (a longstanding desideratum of the cosmetics industry).[64]

I will single out just one of these connections for further discussion. Hooke several times mentions John Dwight, a well-known potter who took out a patent in 1672 for 'making transparent earthenware, commonly knowne by the names of porcelane or China and Persian ware, and also the mistery of makeing the stone ware vulgarly called Collogne ware' (Woodcroft 1854, 34). Dwight opened a pottery at Fulham, and attempted to make all the types of ceramics imported into England at the time. Like many others he was particularly keen to make porcelain, and excavations at his pottery show that he conducted experimental trials with clays and glazes.[65] Dwight studied at Oxford where he apparently met Hooke and Robert Boyle, and he later wrote that these two men supported his endeavours, a claim that there is no reason to doubt. In 1673 he

[62] Birch 1756-7, 3:111 (27 November 1673).
[63] 4 January 1679 (Hooke 1935b, 391).
[64] 23 August 1677 (Hooke 1935b, 308).
[65] For further information see Haselgrove and Murray 1979, Haselgrove and Murray 1992, and Green 1999.

confided to Hooke his secret for making salt-glazed stoneware: 'he told me he used salt to throw into his fire as the Dutch'; and in 1674 Hooke saw some of the results and was impressed: 'Saw Mr Dwights English china. Dr Willis his head, A little boye with a hauke on his fist, Severall little Jarrs of severall colours all exceeding hard as a flint, Very light, of very good shape. The performance very admirable and outdoing any European potters.'[66] Dwight was unusual in that his figures were modelled rather than cast from moulds. Early in 1675 Hooke showed one at a meeting of the Royal Society: 'Mr Hooke brought in an artifical head resembling china, made in England, of English clay, so hard and solid, that he said, that nothing would fasten on it, except a diamond; and that it received its polish in the fire'.[67] This durability was possibily of interest to Hooke because of his various architectural commissions. Dwight was able to make life-sized portrait busts, and Hooke seems to have thought of him in connection with a bust of Dr Baldwin Hamey the younger for the Royal College of Physicians, whose anatomy theatre Hooke designed.[68]

Dwight's experiments with local materials meant that he was mentioned several times in the Royal Society's meetings. Later in 1675, John Aubrey was asked to bring in to a meeting some of the blue clay 'free from sand, and almost of the same colour of ultramarine' found at Easton Pierse in Wiltshire, 'which clay Mr Dwight supposed to be very fit for porcelane'.[69] Three years later, during a discussion about 'the productions of our own country as to rich and precious stones', Hooke mentioned Dwight in connection with 'a method of making very thick pieces of earth to be burnt [ie. fired], without breaking or chopping'. This was in response to Thomas Povey's claim that he had been attempting to make a 'an urn clay' resembling porphyry, 'but that it would not bake of that thickness without breaking'. Hooke told the meeting that 'Mr Dwight had made

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[66] 20 September 1673, 17 February 1674 (Hooke 1935b, 61, 87).
[67] Birch 1756-7, 3:192 (25 February 1675).
[68] 24 February 1675 (Hooke 1935a, 149).
[69] Birch 1756-7, 3:271, meeting of 30 December 1675. Easton Pierse was Aubrey's birthplace, but he had been forced to sell the estate due to debt.

some heads of earth as big as the life: that his earth was as hard as porphyry: and that the excellency of China-earth was, that it would endure the greatest fire without vitrification' (Birch 1756-7, 3:444-5). In both these instances, Dwight is connected with the ongoing search for ways to replicate imported goods in England. The contributions of Povey, Aubrey, and of course Hooke himself demonstrate that these investigations were not confined to craftsmen, even though the knowledge and expertise of craftsmen such as Dwight was valued by the Fellows.

As well as sculptors such as Edward Pearce, who produced Baldwin Hamey's bust for the Royal College of Physicians, and Caius Cibber, who carved the figures of Melancholy and Raving Madness for Bethlem Hospital, Hooke's architectural work brought him into regular contact with painters.[70] The Physicians also requested that Hooke negotiate with painter Abraham Hondius on their behalf, but despite agreeing a fee of £20 the paintings were not forthcoming, possibly because of a last-minute request for additional payment.[71] Hooke also spoke to Hondius in connection with 'hangings' for the Guildhall.[72] The Physicians' commission may have been passed on to a 'Mr Stevenson', a painter with whom Hooke discussed several projects in the mid-1670s including work for Sir Christopher Wren, a painting of the completed Bethlem Hospital, and a fresco for East India House.[73] In September 1676 he met Robert Streater and Antonio Verrio at Montagu House, although in this case he seems not to have actively commissioned their work.[74]

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[70] For Pearce see Eustace 2011 and for Cibber see Gibson 2008.
[71] 14 and 30 September, 23 December 1674 (Hooke 1935b, 121, 124, 137-8).
[72] 29 January and 22 July 1674 (Hooke 1935b, 83, 113).
[73] This may have been the painter Thomas Stevenson, a somewhat obscure figure. Bainbrigge Buckridge claimed Stevenson 'was bred up under Aggas, and became a good painter, not only in landskip, but also in figures and architecture in distemper. He was especially eminent for scene-painting, tho' his works are not so much in esteem at this day, as when he liv'd.' (de Piles 1744, 413). For mentions of Stevenson see Hooke's diary entries for 3 May 1675, 9 January 1677, 18 January 1677, 12 March 1677, 17 August 1677 (Hooke 1935b, 159, 267, 268, 278, 307).
[74] 5 September 1676 (Hooke 1935b, 248). Kathryn Barron notes that Ralph Montagu had persuaded Verrio to travel to England to work on Montagu House (Barron 2008).

Hooke's familiarity with London's art world meant that he was also able to act as an intermediary for others. For example, he seems to have assisted the coffee-house owner Thomas Garraway in commissioning a memorial monument for his daughter, who died in November 1676. Hooke was not merely one of Garraway's best customers, but clearly a valued associate who received a ring, gloves and a 'favour' at the funeral.[75] Some months later, Garraway showed Hooke his daughter's epitaph, and 'bespoke [a] monument'; the two men met 'Waters', one of Hooke's team of builders, some time afterwards to discuss the monument.[76] His role in liaising with artists and craftsmen meant that it was vital for Hooke to have a good understanding of the fabric and construction of contemporary decorative arts, and their associated costs, as well as an appreciation of their aesthetic qualities, in order to judge whether they were appropriate for use in his various projects. As the previous examples have begun to show, Hooke acted as intermediary between practitioners and patrons or purchasers.[77] How significant might he have been in mediating between the artistic and the experimental philosophical communities? And might Hooke's presence as intermediary have brought about a different kind of exchange from that facilitated by one of the more connoisseurial Fellows, such as Evelyn or Povey? The example of John Dwight excepted, there are relatively few instances of Hooke discussing his experience with artists or craftsmen at meetings of the Royal Society; but he did often have one or more of his Royal Society colleagues with him when he was visiting artists or having coffee-house exchanges with craftsmen. It is perhaps not surprising that many of the instances of contact between the philosophical and artistic communities involve some kind of economic transaction, Hooke and Wren's architectural commissions being a prime example.

There were, however, other kinds of contact that were not primarily economic.

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[75] 14 November 1676 (Hooke 1935b, 256; Robinson and Adams transcribed 'fauour' as 'fan and').
[76] 11 July 1677, 21 September 1677 (Hooke 1935b, 301, 314).
[77] See also Sachiko Kusukawa's article in the present volume, and Maddison 1959.

[Fig. 1. Robert Hooke's illustration of hat-makers at work, c. 1666. Ink and grey wash on paper. 187 x 297 mm. Royal Society Archives Cl.P/20/96. (photo: Royal Society).]

Figure 1 is the illustration that accompanied Hooke's description of the process of making felt hats, which he presented at a meeting of some Royal Society Fellows in February 1666.[78] Part of the Society's short-lived 'history of trades' research programme, the text and image document the many steps involved in making hats.[79] They also demonstrate Hooke's close attention to the process: he must have watched the craftsmen at work and questioned them over a period of time (hours, if not days). Even though all the stages of hat-making are depicted here as though they take place simultaneously, the accompanying text goes to some lengths to make clear the time required: not all these processes happen at once. Much of the description concentrates on the 'instruments' of the art, including the workshop tables, the 'bowstick' used to work the wool, the forms on which pieces of felt are moulded, and even the special shirtcuffs worn by felt-makers. Equal attention is given to the materials, which included different types of wood, glue, paper, wool, urine, and wine lees.

The text gives a great sense of the complexity of the process, and reveals, I think unconsciously, the difficulty an outsider would have in trying to understand what was going on. This level of attention to the details of the hat-making craft elevates the status of mechanical labour, as does Hooke's language. Hooke refers to the felt-makers at one point as 'operators' but later as 'artists'. Of course artist in one sense at this time simply meant a craftsman, or artisan, but it usually also implied expertise.[80] In his written account, Hooke conveyed his view of the felt-makers as skilled craftsmen able to work their sometimes intractable materials to produce the desired outcome.

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[78] See Hunter 2013, 90-1.
[79] On the 'history of trades' see Ochs 1985.
[80] See in particular "artist, n.", sect. 2. (*Oxford English Dictionary Online* 2018).

The description of the felt-makers, however, seems ultimately to have been unsuccessful. It does not seem to have been published, even though the instructions written onto the illustration show that it was intended to be printed. More significantly, Hooke claimed at the outset that he would draw some further conclusions from his study:

> In deliuering you a history of this Art I shall first explaine their tooles & Instruments. Next their materialls & manner of working and thirdly I shall indeauour to draw some inferences from my obseruations & shew what information they afford vs for the finding out the operations of Nature[.] Lastly some conjectures or attempts how this art may be varyed or improud either as to the materialls on which they work or as to the instruments & manner of their working or both.[81]

He failed to go on to the third and fourth aims, perhaps suggesting that at this point in the scientific endeavour it was difficult to connect instances of specific art or craft knowledge with wider theories of the natural world.[82]

That is not to say that observations of craft practices such as hat-making were a waste of Hooke's time. On the contrary, some of the instruments or processes associated with art or craft could be used to aid understanding of the natural world, and its own physical processes. For example, when he was describing the bristles on a fly's foot in *Micrographia*, Hooke compared them with the bristles on the cards used to comb wool for felt. Further, he described the fly's action in cleaning its feet by brushing the bristles against each other as cleaning them 'in the same manner as I have observ'd those that Card Wool, to cleanse their Cards, by placing their Cards, so as the teeth of both look the same way, and then rubbing them one against another' (Hooke 1665, 176).

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[81] Royal Society archives Cl.P/20/96, 1[r].

[82] Compare Hooke's ambition here with his discussion of what should be looked for in histories of trades in his 'General Scheme' (Hooke 1705, 26-27), and in his 'Lectures of Things Requisite to a N[a]t[u]ral History' (Oldroyd 1987, 156-8).

Micrographia was published in 1665, probably before Hooke visited the hat-makers and wrote his detailed description of their working practices, but woollen manufactures were widespread at the time and no doubt women carding wool were a common sight in rural England if not in central London.

This is a fairly straightforward example, but Hooke was also inspired by material processes in more complex ways. A craftsman's workshop is a kind of experimental place: a laboratory in which materials are tested and different effects observed. In his 'General Scheme . . . of the present state of natural philosophy', Hooke enumerated all the ways in which natural philosophers could discover the 'workings of nature' – twenty-nine methods in total. The first eighteen involved close scrutiny of natural objects and processes, but the latter eleven methods involved comparing nature with art. 'And for this purpose', Hooke argued, 'it would be very requisite to have a perfect Account of all the Productions of Art, such as are dispers'd up and down in several Trades and Occupations of Men, whether for Profit or Pleasure'. The example Hooke provided to illustrate this idea was to 'compare Paper or Hats with the Skin of an Animal', because the textures of all three materials seemed to have something in common, and therefore perhaps the method of artificial production of paper and hats, or indeed 'Silks, and Cloths, and Linnen' might in some way mimic the body's natural production of skin (Hooke 1705, 57).[83] For Hooke, the key was to compare the *'working of Nature*' with as many mechanical processes as possible: 'For this will not only make the Mind very attent, and earnest, and circumspect, in observing, but will also hint many considerable Circumstances to be inquir'd after, and Experiments for examining and explicating of them' (Hooke 1705, 61).

Hooke used this method himself in *Micrographia*, where he described the optical effect of watered silk, one of the few man-made artefacts he considered worth his attention. He explained that the shifting tones of the silk are caused by reflections from

[83] See also Hunter 2013, 91-2.

the surfaces of the individual threads which 'are by the Mechanical process of watering, *creas'd* or *angled* in another kind of posture then they were by the weaving'. He did not leave the explanation at this, but went on to give an account of the whole manufacturing process so that readers would be clear about the cause, as well as the effect. He finished with the suggestion that the same properties of reflection explain why 'a small breez or gale of wind ruffling the surface of a smooth water, makes it appear black'. By understanding the mechanical process of watering silk, an experimentalist might begin to understand what Hooke refers to as 'multitudes of other phænomena' in the natural world (Hooke 1665, 9-10).

Hooke's interest in art and craft was at the same time theoretical and philosophical, functional, and, perhaps to a lesser extent, aesthetic. It should be clear from the preceding paragraphs that Hooke thought in metaphors, or what he called 'similitudes', and that these had a strong visual element. His philosophical methodology argued that familiarity with as many mechanical processes as possible would help him to understand and theorise the workings of the natural world (Henderson 2019). It is probably no coincidence, then, that Hooke surrounded himself with artists and craftsmen. The relationships covered here represent just a small fraction of those recorded in his diary: the diary is witness to other exchanges with map-makers, model-makers, instrument-makers, glass-makers, further painters, sculptors, and master-craftsmen, and conversations with people who were themselves witnesses to art or craft practices, such as travellers, projectors and collectors.

Part II: Familiar and unfamiliar things

Sachiko Kusukawa's study in the present volume demonstrates the wide-ranging ways in which Royal Society Fellows, individually and as a body, were interested in images; Sietske Fransen and Katherine Rinehart show how committed Antoni van Leeuwenhoek

and Richard Waller were to commissioning and making images. Brian Cowan, though he stopped short of calling the Royal Society 'England's first royal academy of art', has argued that the early Fellows played an important role in setting aesthetic standards in post-Restoration England (Cowan 2004, 170). I would argue, though, that despite their strong interest in materials and practical matters pertaining to art and craft, there were relatively few occasions on which Fellows brought their connoisseurial interests and expertise to bear on the epistemic images produced and consumed at the Royal Society. The minutes of meetings record many requests for drawings of natural history and other artefacts, but little discussion of how this might best be done. It is clear that a number of local professional artists and engravers were valued as informants and producers of scientific illustrations, but none were elected as Fellows in this period. Here I would like to suggest that part of the reason for this somewhat surprising omission might have been a concern about the seductive nature of art, and its potential to influence the passions.[84] There were of course other reasons why artists may not have attended Royal Society meetings. The early Fellows were slow to admit men engaged in trade, although some were elected. Men engaged in busy professional careers may not have had the time to attend meetings. The Society's precarious status in its early years may have meant that high-profile artists such as Streater and Lely saw no particular benefit to being a member, since they already had access to the aristocratic clientele from whose circles the Society's Fellows were largely drawn. It seems to me, though, that there may have been more philosophical reasons for the Royal Society to be wary of artists. As Pamela Smith has shown, early modern natural philosophers considered the human senses, and particularly sight, to be dangerous because they produced the strongest impressions on the mind, confusing the faculty of reason and

[84] Brian Cowan has made this suggestion in the course of his discussion of the extent to which the Royal Society might be seen as central to English connoisseurship in the late seventeenth century, citing the evidence of Abraham Cowley's prefatory poem in Thomas Sprat's *History of the Royal Society* but not elaborating further (Cowan 2004, 174; citing Sprat 1667, sig. B2^{r}).

eliciting an emotional response (Smith 1999, 428, 446).[85] This was not always negative. John Evelyn in his printed treatise *Sculptura: or the history and art of chalcography and engraving in copper* (1662) wrote, approvingly, that the drawing pen has 'attain'd its desired end, when it so deceives the eye by the *Magic,* and innocent *Witch-craft* of lights and shades, that elevated, and solid bodies in *Nature,* may seem swelling, and to be embossed in *Plano,* by Art.' He also discussed the benefits of images in children's education, suggesting that young minds might be 'allured and courted' into knowledge through pictures, 'which naturally slide into their fluid, and tender apprehensions, speedily possessing their memories, and with infinite delight, preparing them for the more profound and solid studies' (Evelyn 1662, 141-2).[86]

The language used by Evelyn here about images recalls contemporary debate about rhetoric, which also had the capacity to deceive listeners, or to persuade them through an appeal to the passions rather than the reason. Evelyn himself linked rhetorical skill with artistic skill, writing that 'it is worth the observation, that the Ages which did most excell in *Eloquence*, did also flourish most in these *Arts* [ie. 'cutting and Engraving'], as in the time of *Demosthenes* and the same *Cicero*; and as they appear'd, so they commonly vanish'd together' (Evelyn 1662, 134).[87] The Royal Society as an institution claimed to reject rhetorical excess, and in various of their writings Fellows advocated a 'plain style' which as Thomas Sprat famously put it, would deliver 'so many things, almost in an equal number of words' (Sprat 1667, 62, 113).[88] Hooke himself, while discussing the best way to record natural histories, advised 'avoiding all kinds of Rhetorical Flourishes, or Oratorical Garnishes' and instead choosing language of 'the

[85] See also Hunter 2013, 88-89; and Kusukawa, present volume.
[86] The primacy of sight, and its significance for the memory, had been argued by Cicero and was a scholastic commonplace (Cicero [1942] 1948, 2.87.357). See also Kusukawa's discussion of Evelyn's comments in her article in the present volume.
[87] See also comparisons by Franciscus Junius (Junius 1638, 1.4:44ff) and William Sanderson (Sanderson 1658, 12-13).
[88] The extent to which Royal Society Fellows and others rejected rhetoric in favour of a plain style has been much discussed by literary scholars over the past century: see in particular Jones 1930, Vickers 1985, Preston 2013, Nate 2014.

greatest Plainness and Significancy' (Hooke 1705, 63). He then moved to a discussion of the best use of images. He agreed that pictures could often express more than words, and could therefore be a useful addition to text.

> Now because oftentimes much more may be expressed in a small Picture of the thing, than can be done by a Description of the same thing in as many words as will fill a Sheet; it will be often necessary to add the Pictures of those Observables that will not otherwise be so fully and sensibly exprest by Verbal Description: But in the doing of this, as a great Art and Circumspection is to be used in the Delineation, so ought there to be very much Judgment and Caution in the use of it. For the Pictures of things which only serve for Ornament or Pleasure, or the Explication of things as can be better describ'd by words, is rather noxious than useful, and serves to divert and disturb the Mind, and sways it with a kind of Partiality or Respect: Besides that, it fills up room, and occupies the Mind with the Ideas of things which are little significant in the present Inquiry.
>
> And therefore all those kind of Pictures of the outward Forms and Beauties, and Varieties of the Species of Nature, are to be referred to another Head, where indeed they will prove very significant, but to a peculiar kind of Inquiry . . . (Hooke 1705, 64-65)

This part of Hooke's method is devoted to his 'Philosophical Algebra', a working method that he never fully explained but which seems to have relied on compressing information into as small a space as possible in order to access it quickly.[89] Thus it may not be surprising that he banned superfluous images. It is clear, however, that merely ornamental or pleasurable words and pictures are equally to be avoided not just because they take up space but because they are equally distracting, and that this includes 'Pictures of the outward Forms and Beauties, and Varieties of the Species of

[89] For further discussion of the philosophical algebra see Hesse 1966.

Nature'. There is a place for this kind of image, we are told, but Hooke seems never to have completed the second part of his method and the 'peculiar kind of Inquiry' to which these pictures are significant remains a mystery.

It may seem strange to suggest that Hooke, who had produced one of the most lavishly-illustrated volumes of early science, might have been wary of images. And yet, it seems to me that just as they continued to use rhetoric in their written works, the Royal Society Fellows used visual rhetoric to their advantage while at the same time remaining conscious of its pernicious qualities. That is, they deliberately constructed images that were intended to sway the mind 'with a kind of Partiality or Respect', to use Hooke's language. The analysis of the famous frontispiece to Thomas Sprat's *History of the Royal Society* (London, 1667) by Michael Hunter and Jim Bennet demonstrates the careful construction of this very public image designed to promote early institutional science (Hunter 2017). In a richly suggestive study, Matthew C. Hunter has explored many of the ways in which Restoration science engaged with the visual arts (Hunter 2013). Meghan Doherty has demonstrated that Hooke used the 'visual vocabulary' developed by contemporary portrait engravers in his illustrations for *Micrographia*, a vocabulary that was familiar to viewers and thus helped them to understand what was being depicted (Doherty 2012). John T. Harwood has argued that the rhetoric of Hooke's illustrations and text worked together to produce *enargeia* for the audience (Harwood 1989). In the case of Hooke's *Micrographia*, a book aimed at a wider audience than simply the philosophical community, and one in which the core argument is that the world is not as it seems, we may not be surprised that the illustrations are designed to provoke wonder and curiosity, and sway the audience's passions even before appealing to their reason.

[Fig. 2. Robert Hooke's drawing of Francis Potter's suggested cart with legs, 1663. Ink on paper. 184 x 295 mm. Royal Society archives EL/P1/40. (photo: Royal Society).]

The appeal to the passions, though, can be seen in a broader range of images. In 1663, the clergyman and inventor Francis Potter sent John Aubrey a paper outlining his newly-invented cart with legs instead of wheels. Aubrey presented the paper and accompanying diagrams at a meeting of the Royal Society, where it was 'referred to the consideration of Mr Hooke', who was asked to bring in a report of it to the next meeting.[90] Hooke's written report, presented two weeks later, pointed out various drawbacks to the design, including the difficulty of reversing the cart. The report was ordered to be sent to Potter 'with some alterations' (one suspects, toning down the criticism); but the Fellows were obviously intrigued enough also to order Hooke to write up a 'full description' of the cart, along with a 'scheme' of it, so 'that it might be entered with the animadversions'; that is, transcribed into the Society's Register Book.[91] The illustration reproduced here as Figure 2 is presumably the 'scheme' Hooke produced in response to the request. Instead of depicting only the mechanism, though, as Potter's original diagrams had done, Hooke's image represents the cart as a whole, including the horse. In doing so, he encouraged viewers to participate in a joke. He used a convention which had become standard in natural philosophical illustrations, the alphabetized labelling of different aspects of the drawing; but instead of aiding interpretation, here it merely invites mockery of the content. His initial instruction, 'Let h denote a horse', suggests his viewers need help interpreting even the most obvious aspect of the image, so outlandish is the contraption depicted: the established rhetoric of the scientific image is subverted in order to make a point about the quality of the 'science' on display. Labelling 'f' for the contraption's 'feet' and 'k' for the 'knees' also seems somewhat redundant and runs counter to the more common practice of labelling parts in alphabetical order. More fundamentally, calling these contrivances 'leggs', 'knees' and 'feet' emphasises the comical distance between functional nature and this ineffectual

[90] Birch 1756-7, 1:206 (meeting of 4 March 1663).
[91] Birch 1756-7, 1:207 (meeting of 18 March 1663).

engine. As though to underscore this point, the legs of the patient horse stand juxtaposed with the cart's artificial legs in silent reproof.

[Fig. 3. Thistle stalk, Tab. 38 in Nehemiah Grew's *The Anatomy of Plants* (London, 1682). Folio. (photo: Royal Society).]

The illustrations in Nehemiah Grew's *The Anatomy of Plants* (London, 1682) seem designed to surprise their viewers in different ways. This was a ground-breaking botanical work in which Grew studied the macroscopic and microscopic structures of plants.[92] He cites Hooke's *Micrographia* several times during the work, and the detailed illustrations surely owe some debt to Hooke's work as well. Printed in a similarly lavish folio volume also dedicated to Charles II, Grew's intricate plates seem designed to highlight the beauty and symmetry of nature just as Hooke's did in *Micrographia*. Like Hooke, Grew introduced his readers to a 'new World', in which 'one who walks about with the meanest *Stick*, holds a Piece of Natures Handicraft, which far surpasses the most elaborate *Woof* or *Needle-Work* in the World' (Grew 1682, [π]^{v}, [π2]^{r} italics reversed). Grew noted of the illustrations:

> In the *Plates*, for the clearer conception of the *Part* described, I have represented it, generally, as entire, as its being magnified to some good degree, would bear. So, for instance, not the *Barque*, *Wood*, or *Pith* of a *Root* or *Tree*, by it self; but at least, some portion of all three together: Whereby, both their *Texture*, and also their Relation one to another, and the *Fabrick* of the whole, may be observed at one *View*. . . . Some of the *Plates*, especially those which I did not draw to the *Engravers* hand, are a little hard and stiff: but they are all well enough done, to represent what they intend. (Grew 1682, a4^{v})

[92] On Grew's images see Coppola 2013.

Many of the plates do what is not mentioned here, and represent a naked-eye view of the specimen alongside the magnified view, as Hooke had done with a printed full-stop in *Micrographia*. In the plate reproduced above as Figure 3, the enlarged section of thistle stalk is labelled 'The same' alongside an illustration representing the section in its actual size. And yet the two illustrations are not the same: although carefully oriented in the same direction, they are strikingly different. Telling readers that the two objects depicted are 'the same' only highlights the difference between the two drawings of them – if the similarity were obvious then the label would not be required. The magnified thistle demonstrates the mathematical regularity and order found in nature, a point Grew insisted upon in his dedication to Charles II: all the parts of a plant, he claimed, 'are as artificially made; and for their *Place* and *Number*, as punctually set together; as all the *Mathematick Lines* of a *Flower* or *Face'* (Grew 1682, [π]^{v} italics reversed). He is arguing here that plants are just as worthy of study as animals, but his choice of comparison suggests that he had aesthetic qualities in mind alongside the geometry of the structures he was observing. The 'Mathematick Lines' of faces had been explained by Dürer, whose work was widely available in popular form in England (Dürer 1652); Grew himself developed a theory of the geometrical structure of plants, including their flowers (Grew 1682, 167; Roos 2007, 54-5). In the plate reproduced here, the interlocking circles at the centre of the stem with their web-like internal structures provide a contrasting texture to the hollow pores or cells into which they merge at the outer part of the stem. They recall one of Grew's most prominent metaphors for plant structures, that of the loom (seen in the quotation above where he mentions *'Woof* or *Needle-Work*'), linked in the book's dedication with both Athena (powerful 'Nature') and Arachne (human skill) (Grew 1682, [π]^{v}). Grew's plant images, then, play with their viewers: they shift in perspective, juxtaposing naked-eye with microscopic views; they flaunt their mathematical symmetry, asking to be ranked alongside flowers or faces as

subjects worthy of portraiture; and they stand as emblems for figures from classical myth.

[Figure 4: Richard Waller's drawing of millet grass and smooth crested grass, signed 'Ric: Waller pinx[it]'. c. 1689-1713. 380 x 240mm. Graphite, ink and watercolour on paper. Royal Society Archives MS/131/11. (photo: Royal Society).]

It seems to me that Grew and others might have deliberately incorporated these kinds of playful shifts of perspective and other rhetorical techniques into their drawings in order to encourage viewers to look at the subjects depicted with new eyes. Richard Waller was one of the most technically proficient men to produce illustrations for the early Royal Society.[93] His illustrations of common grasses are detailed and instructive, showing the plant as a whole in colour and in as life-like a way as possible, and also providing details of the flower or stem in pencil (figure 4). While the rationale for Waller's choice of subject is not entirely clear, it does demonstrate the concern shown by Hooke and Boyle, discussed above, that common things not be neglected in favour of the exotic. By lavishing his attention on these humble grasses, Waller seems to be asking his audience to look at them with fresh eyes and see them as beautiful, complex organisms.

A very different kind of 'image', Waller's colour chart (figure 5) also challenged its audience to see things differently.[94] Printed in the *Philosophical Transactions* with the aim of standardising the classification of colours, the chart reminded viewers that colour was not simple and stable, but could be separated out into constituent hues; or in the case of Waller's 'simple' colours, into the various organic and inorganic substances used to make the paints listed on the chart. While Waller's intention was to aid natural

[93] See Katherine Reinhart's article in the current volume, and Kusukawa 2011, 2013, and 2015.
[94] On the colour chart see in particular Kusukawa 2015.

philosophers in their descriptions of plants and animals, it also demonstrates that colour is not always quite what it seems. Kusukawa has argued that Waller was partly indebted to Hooke for his colour theory (Kusukawa 2015, 8). Hooke had discussed painters' colours in *Micrographia* as part of a consideration of transparency and opaqueness. He reported,

> Thus have I by gently mixing *Vermilion* and *Bise* dry, produc'd a very fine Purple, or mixt colour, but looking on it with the *Microscope*, I could easily distinguish both the Red and the Blue particles, which did not at all produce the *Phantasm* of Purple. (Hooke 1665, 78)

Hooke moves here from describing the purple colour as 'very fine', to seeing it as a *'Phantasm'*. A shift in perspective changes reality, and when viewed differently the colour purple is revealed as an illusion. Waller's colour chart, then, acts on two levels: ostensibly directing its viewers in their analysis of coloured objects, it also reminds them that depictions of those objects never tell the full story.

[Figure 5: Richard Waller, 'A Catalogue of Simple and Mixt Colours'. *Philosophical Transactions* Vol. 16 (1686), 24-32. Quarto. (photo: Royal Society)]

Conclusion

I began this article with an account of Hooke's methodological writings, in which he suggests that ideally the experimental philosopher should behave as both novice and expert at the same time. I would like to suggest that the underlying tension in this position, and the tension between the need to use an accepted visual rhetoric and a feeling of suspicion towards it, might have influenced the production and consumption of scientific images in the early Royal Society. Throughout his writing Hooke demonstrated his preoccupation with the knowledge that things are not what they

seem. For Hooke, this stemmed from his microscopy, but in the wider world of natural philosophy it was borne out by research in astronomy, anatomy, geology, and by speculation on the fallibility of the human senses. Hooke constantly returned to the idea that there is always more than one way of seeing something, that subjects should always be inspected from multiple viewpoints, and that the human view of the natural world is not necessarily the correct one. This does not merely extend to the physical aspects of an object, but is also about the place the object occupies in a wider world-view: for example, a flea can be both a pest and a noble animal at the same time. For Hooke, knowing the truth about something meant holding multiple conflicting views in mind simultaneously: a difficult situation to represent graphically.

How might Hooke's fellow Royal Society Fellows have experienced this sense of dissonance (if at all)? Curiously, the weekly meeting as a performative space was an ideal venue in which to present things as both strange and familiar. The very fact of producing an object at a meeting, and subjecting it to the scrutiny of the Fellows, brought it out of its ordinary milieu and into the cognitive realm of natural philosophy. Scientific instruments could help with this transition: perhaps the most striking being the air-pump, which helped (through its absence) to transform that most mundane of substances, air, into something with unexpected properties, and something that should be looked at, rather than looked through. Viewing and handling items at meetings was crucial to comprehending them, parallel to the process of viewing and understanding art and craft manufacturing processes as discussed above. Having been presented and discussed at meetings, it was often ordered that scientific communications be 'registered' – that is, inserted into the collective memory by being copied into the Society's Register Books, or Letter Books. Registering items positioned them in a philosophical framework, just as adding solid artefacts to the Society's Repository, or museum collection, inserted them into a taxonomic framework for the natural world. Diagrams and illustrations were regularly required for both these collections. Just as the

process of scrutinizing objects at Royal Society meetings and discussing their properties, origins or meaning removed them from their familiar contexts, so the process of drawing them for the purposes of 'registering' implied a new recognition of their significance, and a new, more expert understanding of them.

It is clear that in his scientific life Hooke valued the skill of being able to see things differently, and I think we can argue that looking at art and craft practices helped him to do this.[95] His (and others') concern with processes stemmed from an understanding that in order to see something correctly one needs to know it intimately, and a belief that similar processes produce similar effects in human endeavours and in the natural world. However, the interactions outlined in the first part of this article demonstrate that there was much more going on than simply a philosophical interest in processes and materials. Hooke's interactions with art and artists had a number of different aspects, depending on the specific occasion. There are of course a number of instances when Hooke is seen to be making experiments himself, or suggestions towards improvements to techniques, or discussing new methods. Other occasions involved what we might think of as connoisseurship: that is, Hooke is appreciating or critiqueing art; reflecting on the product in light of what he knows of the techniques and materials of production, or the identity of the artist or sitter; or appraising artefacts for his own collection or in the collections of others. This could shade into an educational function for art, where the artefacts are used for instruction in a practical sense rather than in the more theoretical natural philosophical sense, either for Hooke himself, or in order to help him instruct others. And on a number of occasions we have seen Hooke commissioning work, or discussing potential commissions, reminding us again of the economic significance of art and craft for Hooke and others. Of course we should not separate these different aspects too strictly: as we have seen, many of the interactions

[95] Doherty argues that Hooke's art training enabled him to see things that others could not, in their true form (Doherty 2012, 211).

noted in Hooke's diary relate to new processes and materials, or optimisation of existing processes, but it is difficult to decide whether he recorded these conversations for their philosophical content, or because he sensed a possibility for financial gain (for himself or others). Most importantly, Hooke's activities reinforce the understanding that many of these endeavours were collaborative processes. The boundaries between producers and consumers, patrons and clients, artists, craftsmen, experimenters and inventors were fluid, and individuals could take on more than one of these roles.[96]

If there was a need to make things both strange and familiar at once, to make viewers both accept and feel uncomfortable with the subject matter, then I think Hooke and his colleagues must have found common ground with their artist associates. Representing things as familiar reminds viewers of their existing experiential knowledge of the natural world: they already have an image in their mind's eye of a thistle stalk or a printed full-stop, and (generally speaking) they know how these things are produced and what they do. Representing objects as unfamiliar demands that viewers stop to take a second view, to ask why things are the way they are, and what their relationships might be with the universe around them: in short, the kinds of questions that science asks.

[96] On this kind of 'distributed ingenuity' see Marr 2018.

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