‘*A sincere hand and a faithful eye*’: the many interests of Robert Hooke (1635–1703)

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Abstract. Since the tercentenary of Hooke’s death, Hooke’s polymathic interests have received much scholarly attention. This paper discusses his interests as reflected via his drawings, which are perhaps less well known. His drawings played an important part in scientific record-keeping at the Royal Society and enabled visualisation of manufacturing processes, objects, mechanisms and theories. His graphic skills were important tools for his observational and empirical studies. Hooke’s artistic ability is therefore a worthy addition to his many-sided talents.

1. Introduction

The tercentenary of Robert Hooke’s death in 2003 inspired a flurry of biographies and studies, all of which acknowledged his multi-faceted interests that ranged from astronomy, kinematics, dynamics, instruments, horology, architecture, weather, geology, harmony, history, medicine, languages to improving dyeing, varnishing, calico printing, and porcelain [1]. Particularly significant for our historical understanding of Hooke has been the work of the late Jim Bennett (1947-2023), Director of the Museum of History of Science, Oxford (1994-2010), and Curator of the Whipple Museum of the History of Science, Cambridge (1979-1994), who demonstrated the contribution of practical mathematics to natural philosophy on the basis of a deep understanding of period instruments [2]. Instead of attempting to offer a comprehensive coverage of Hooke’s activities, This paper discusses his interests as reflected in his drawings, which are perhaps less well known [3]. His artistic skill, it is argued, is a worthy addition to his many-sided talents, because they were critical to his scientific endeavours.

Hooke’s view of natural philosophy is encapsulated by the phrase, ‘*a sincere hand and a faithful eye*’, which occurs in the preface of his best-known publication, *Micrographia* (1665) [4]. The phrase is related to Hooke’s belief, shared by many at the time, that the human capacity for sense perception and knowledge had been corrupted because of Original Sin. Before the Fall, Adam was capable of sharp perception and knowledge that current humans were not capable of. The brain, imagination, and memory had also been affected and become fallible, resulting in dogmatic and erroneous philosophy that needed to be corrected and established anew. Reforming natural philosophy thus required rectifying the limited power of the human senses. This could be achieved, Hooke stated, with instruments that acted as ‘artificial organs’ for humans. This belief underpinned his constant drive for instruments with finer measurement and greater accuracy. Instruments were what made the hand sincere and the eye faithful for rebuilding natural philosophy.

Hooke’s belief in the need to augment human vision with instruments also explains his frustration with the Polish astronomer Johannes Hevelius (1611–1687), who refused to use with his telescope the micrometer, a screw-adjustable set of wires fitted in front of the eyepiece that enabled measurement of small angles by means of the screw's rotation. Hevelius claimed he did not need a micrometer because he could measure a fifth or a tenth of an arcminute using transversal lines marked on his instruments, which he illustrated in his *Machina coelestis* (1673). An examination of Hevelius's illustration of the transversal markings with a 'magnifying glass' revealed, according to Hooke, that they were uneven and thus inaccurate, due to '*a naked eye and an unmachined hand*' [5]. This was the opposite of a '*sincere hand and a faithful eye*', where instruments were essential in correcting and augmenting the limitation of the human senses.

Hooke was not the only person to advocate the usefulness of instrumental observation in this period, but this hand-eye co-ordination was uniquely effective in Hooke because of his artistic training. As Richard Waller (c. 1646–1715), Hooke's friend and first biographer, noted, Hooke was graphically proficient as a child, and after his father's death in 1648 and before attending Westminster School (1649 or 1650), he was apprenticed to Peter Lely (Pieter van der Faest (1618–1680)), the well-known portraitist at the time: "*I understand he was for some time with Sir Peter Lely, how long I am not certain: I suppose but a short time; for I have heard that the smell of the Oil Colours did not agree with his Constitution, increasing his Head-ach[e], to which he was ever too much subject,*" [6]

Hooke's graphic skill must have been promptly recognised by the early members of the Royal Society, as he swiftly became the Society's de facto draughtsman and was considered the most suitable person to be entrusted with the work for what became the *Micrographia*. The first part of this paper will discuss some of the drawings Hooke made for the Royal Society, including those of his instruments. These examples highlight the important role of drawings for the early Royal Society. It will then discuss how his graphic skills were crucial to his microscopical observations and the study of fossils. The ability to interpret shadows and reflections and the skill in expressing details of three-dimensional objects on paper were important tools for observational and empirical studies of nature. Drawing is therefore an important ability to be counted among Hooke's many talents, even if it is not obvious that Hooke saw himself as a polymath.

2. Hooke's Royal Society drawings

2.1. Drawings for the Royal Society

Figure 1. Drawing of the bladder stone of Sir Thomas Adams (1668), red chalk with white highlights on blue paper 240 x 280 mm by Robert Hooke CLP/ 14i/22 © The Royal Society

From its inception, the Royal Society maintained a record of its meetings and decisions, not all of which could be captured by textual description [7]. Complex devices, instrumental observations, manufacturing processes or unusual objects benefited from being recorded in images rather than by textual descriptions alone [8]. Hooke's graphic skills enabled visualisation and documentation of what interested the early Royal Society. For example, Hooke used a single-point perspective for a view of a Hampshire salt mine (1666), and deftly applied ink wash to model 'stones' extracted from the heart of the late Charles Lindsay, the Earl of Balcarres (1663) [9]. Hooke was also ordered to 'draw the figure' of the bladder stone (1668) of Sir Thomas Adams, a former Mayor of London, extracted after his death (figure 1). The stone weighed '*twenty-two ounces and three eighths Troy weight*' (696 grams) with a gutter in the middle through which it was presumed that the urine passed, since Adams apparently did not complain of any symptoms until just before he died [10]. Unusually, Hooke drew this object on blue paper using red and white chalk. This was a well-known combination of material used by Old Masters to elevate their drawings to a work of art. Hooke may well have been familiar with such styles of drawings through Peter Lely's collection, which included a drawing of a kneeling nun (c. 1612) by Rutilio Manetti (1571–1639) in red chalk and white highlights on blue paper, now in the British Museum [11]. Hooke's drawing of possibly the most artistically rendered bladder stone in this period displays his virtuosic command of the artists' medium.

Not everything that Hooke drew were of actual objects or instruments that had been constructed or used. Hooke was requested to make a 'scheme' of a device that was rather poorly described in a letter by Francis Potter, a rector at Kilmington, Devon, communicated to the Society by a fellow, John Aubrey in 1663 [12]. The legend to the sketch (figure 2), instead of in the usual alphabetical order, starts with h: '*Let h denote a horse*', followed by '*CC a cart with 4 leggs, ffff the feet of these legs...*' A hint of sarcasm reflects Hooke's view of the device as '*noe ways soe convenient & usefull as a Cart with wheels*' [13]. Hooke's vivid ink sketch of the cart fastened onto a horse renders this design all the more absurd.

Figure 2. Robert Hooke's reconstruction of the design of a cart with legs by Francis Potter (1663), ink on paper 184 x 295 mm EL/P1/40 © The Royal Society

Some of Hooke's drawings found outside the Royal Society were also made in relation to the Royal Society. For example, among the papers now at the Royal College of Physicians, London, of Edward Tyson (1650–1708), a fellow of the Royal Society and also a fellow of the Royal College of Physicians, are drawings in grey wash and ink of the anatomy of a harbour porpoise (*Phocoena phocoena*) that Hooke had helped to dissect. Tyson acknowledged Hooke's assistance in the resulting publication, *Phocaena, or the anatomy of a porpess, dissected at Gresham Colledge* (1680), where Hooke's drawings served as the basis of the engraved illustrations [14]. There is also a hitherto unnoticed drawing by Hooke in the British Library, unfortunately torn, of an 'Indian' bat (figure 3). Hooke had placed the bat prone on paper, drew its outlines, and then recorded the measurements of its wing [15]. The label, in Hooke's hand, pasted on the drawing reads: 'The measures of an Indian Bat taken in the Repository of the Royall Society at Gresham Colledge May 25 1679 by R. Hooke'. The date of this measurement falls between his two reports to the Royal Society on flying. On 8 May 1679, Hooke had demonstrated with pasteboards the design of a 'flying machine' reported in *Journal des Sçavans* (1678) and on 5 June he described the flaws in the idea of a ship floated by copper spheres evacuated of air, as described in Francesco Lana's book, *Prodromo* (1670) [16]. The date suggests that Hooke's study of the bat belonged to his long-standing interest in flight.

2.2. Drawings of instruments

By far the most numerous of Hooke's drawings surviving in the Royal Society are draughts of his own instruments that accompanied his reports read at its meetings. Three examples from 1663 illustrate the different ways – as Jim Bennett has pointed out – in which Hooke used instruments, namely for measurement, discovery, theorisation, and explication of theories [17].

Hooke drew his design of the 'wheel barometer' from an angle to show its mechanism (figure 4). It was essentially a modified barometer for detecting small changes in atmospheric pressure [18]. A mercury tube with a cistern closed at the top was bent at the other (open) end with a small steel bullet as a float on the surface of the mercury. The float was attached to a silk thread running over a cylinder that was connected to the index of a wheel with a counterweight on the other end of the thread. The movement of the float was transferred to the index of a larger disc whose outer limb was divided into 200 parts. In the same spirit as the micrometer, this instrument promised precise measurement of very small values, and a drawing helped explain its mechanism. This was a design submitted to a meeting of the Royal Society along with other designs of instruments for weather observation.

Figure 4 Drawing of the mechanism of a wheel barometer (1663), ink and wash on paper CLP/20/32 © The Royal Society

Figure 3 Robert Hooke's measurement of a bat, ink on paper pasted on large dark purple paper 51.5 cm x 35 cm. © Courtesy of the British Library Board (Add MS 5272 fol 10r)

Hooke also showed a time-lapse image (figure 5) to illustrate the workings of an instrument for discovery, i.e. to fetch a sample of water from any depth of the sea. The design was considered original enough to be recorded in the Society's 'Register Book' [19]. The box drawn in red indicates its state as it is lowered down the sea, with its lid and bottom panel open. The box in grey shows that when it is pulled up the lid and bottom panel close with the pressure of the water. This would enable samples of water to be collected from various depths of the sea for various analyses.

Figure 5 Drawing of an apparatus for fetching up water from any depth of the sea (1663), ink, wash and chalk on paper CLP/20/35 © The Royal Society

Figure 6 Drawing of an instrument for finding the force of falling bodies (1663), ink on paper CLP/20/12 © The Royal Society

While the images of the wheel barometer and the water-fetching bucket were submitted to the meetings as designs (not necessarily constructed at that point), Hooke also drew an instrument that was made and used by him. For example, he presented the design of the instrument to measure the height from which a pellet should be dropped in order to nudge a weight several times its own weight (figure 6) alongside the results of the experiments using the instrument. Though this instrument did involve some precise measurements, Hooke considered this a *philosophical* scale, as he believed it would help him understand the relationship between the force of a falling body and its height [20].

Hooke also used images of instruments to *explain* a theory – for instance, a rule for which he had claimed priority using an 'anagram' that was revealed two years later as 'ut tensio sic vis', namely that the power of the spring is in proportion with the spring's tension [21]. He illustrated this rule visually in the accompanying diagram (figure 7). A helical coil and a 'watch spring' are shown with a scale marked E in both cases. F to N indicate in increasing sizes the weights weighing 1 to 8 in proportion to one another. Placing one of these weights on the scale would make the coil stretch in length also proportional to each other. The points to which a coil would stretch are marked as equally spaced points underneath the scale from o to w for both the helical coil and the watch spring. In the accompanying text, Hooke first described how his law applied to a helical coil, then pointed out that the same was true for the watch spring, and finally noted that in the case of a straight wire it was so 'plain' that there was no need to explain it by a figure (though a figure of the straight wire is added in the illustration). This illustration thus visually instantiated what his general rule meant in three cases. Hooke then extrapolated in the text, without any further demonstration or illustrated, that his rule was applicable to all other 'springy bodies', be it '*Metal, Wood, Stones, baked Earths, Hair, Horns, Silk, Bones, Sinews, Glass, and the like*' [22]. Hooke's images of instruments were thus a visual expression and confirmation of his belief in the importance of instruments in developing and communicating natural philosophy.

3. Observation and extrapolation

3.1. Microscopic observation

Hooke's graphic skills were also crucial for his microscopic observations that underpinned the illustrations of *Micrographia*. As a result of the King's wishes to see more microscopic drawings of insects like the ones Christopher Wren had shown him, but Wren being too busy, Hooke was tasked to compile a book of microscopic observations for the King. For a year from December 1662 to December 1663, Hooke submitted at least forty drawings of his microscopic observations for approval to the Society's meetings. The drawings were done by Hooke and then turned into printable illustrations for the book by engravers [23]. Unfortunately, only a couple of drawings for *Micrographia* remain in the Royal Society, and it is possible that as Hooke became suspicious of its record-keeping practices, especially by the Secretary, Henry Oldenburg, he withheld papers and sketches from the archive [24].

In the preface to *Micrographia*, Hooke explained how he had to observe the same object multiple times. Whether a black or a white spot on an object was truly a coloured spot on the surface or a shadow or reflection, had to be determined by changing the direction of light, or moving a hand or a stick between the source of light and the object observed, or detecting a reflection of a window. The smoothness of the surface of a steel globule or of the cornea of the mite could be determined by the reflection of the windows [25]. In the case of the 'eyes' (receptors to us) of the horsefly, Hooke even illustrated the reflections of the double windows in Gresham College (figure 8), on the basis of which he deduced that they were rows of hemispheres, not – as another Fellow of the Society, Henry Power, had claimed – '*dimpled with innumerable little cavities*' [26]. This is a rare occasion where Hooke illustrated a stage in the process of his observation before determining the shape of an object observed.

Figure 7 Hooke, *Lectures de potentia restitutiva* (1678) <doi.library.cmu.edu/10.1184/OCLC/10411228>, Carnegie Mellon University Special Collections USA

Figure 8 Detail of scheme XXIII, from Hooke's *Micrographia* (1665), the Lessing J. Rosenwald Collection, Library of Congress, USA

Knowledge of how light falls on surfaces, and how reflections indicate shape or texture of a surface was a fundamental part of artistic training. This helped Hooke interpret what he saw through the microscope. An artistic background was equally important for Galileo in his telescopic observations [27]. Given the quality and limitations of early microscopes and telescopes, artistic training was a critical part of observation techniques.

3.2. Study of ammonites

Hooke's graphic skills also enabled him to move from individual objects to generalisations. The drawing from the British Library (figure 9) shows sixteen ammonites, or 'snakestones' as he called them, of various shapes and sizes and states [28]. Each fossil is carefully depicted and modelled differently using a combination of white and brown wash as well as inked lines. The different manner of depiction has the effect of enhancing the individual character of each fossil. Each fossil casts a shadow reinforcing its physical presence on the page. Added next to the ammonites in line-drawing are their transverse sections (perpendicular to the picture plane), not readily visible from the way the ammonites are laid out. These provide a fuller view of the three-dimensional shapes of the objects. Hooke then added an enlarged leaf-like pattern, as viewed with a magnifying glass, visible on the surface of the ammonite. Hooke thus recorded fossils from multiple viewpoints on one sheet of paper.

While all these specimens consisted of different substances and shapes, Hooke noted that they exhibited some common features. For example, they were all made of tapering bodies that coiled around their tip in the centre with the axis of coiling in the same plane. All of them had ridges and depressions tending toward the centre of the spiral. They also had diaphragms whose patterned edges were visible on the surface with a magnifying lens. Hooke's suspicion was that these 'snake stones' were petrified remains of once living creatures of the sea, rather than concretions formed from the salts of earth (as commonly assumed at the time) and that they were found in hills and mountains as a result of earthquakes. Demonstrating that this was the case was one of his many ongoing interests [29]. This drawing shows empirical observation of individual specimens, visual dissection, and discovery of details with a microscope, all recorded on one sheet of paper, from which Hooke could generalise and hypothesize. Thanks to his artistic training, drawing became an indispensable tool for scientific observation and knowledge for Hooke.

4. Polymath?

Hooke is included among Peter Burke's study of 500 polymaths since the time of Leonardo [30]. 'Polymath' was a word known in the period, indicating those with general learning who mastered many if not all disciplines of knowledge. The first recorded use of the word 'polymath' in an English publication, according to the Oxford English Dictionary, is in Robert Burton's *Anatomy of Melancholy* (1624), where the 'polymath' was invoked alongside the 'polyhistor' as an ideal for omniscience that was already difficult to attain [31]. By the time Hooke died, according to Burke, the age of prodigious polymaths had come to an end, however. Polymaths were more likely to be viewed with suspicion and criticised for being too distracted, a feature Burke calls 'the Leonardo syndrome' [32]. If the curse of a polymath was distractedness, then Hooke's friend Waller would appear to agree that Hooke was one, as he wrote: "It must be confess'd that very many of his Inventions were never brought to the perfection they were capable of, nor put in practice till some other Person either Foreigner or of our own Nation cultivated the Invention, which, when Hooke found, it put him upon the finishing *that which otherwise possibly might have lain 'till this time in its first Defects: Whether this mistake arose from the multiplicity of his Business which did not allow him a sufficient time, or from the fertility of his Invention which hurry'd him on, in the quest of new Entertainments, neglecting the former Discoveries when he was once satisfied of the feazableness and certainty of them, tho' there wanted some small matter to render their use more practicable and general, I know not*." [33] Would Hooke have considered himself a polymath? That is not known.

Although this paper does not insist on the similarities between Hooke and Leonardo, there is one further intriguing historical, indirect connection between the two [34]. That is, from at least 1678, when the library of Henry Howard (1628-1684), the Duke of Norfolk, was moved to Gresham College, Hooke was living and working near a manuscript by Leonardo da Vinci. Howard had expressed his intention in 1667 to donate to the Royal Society the library that included manuscripts and books collected by his grandfather, Thomas Howard, Earl of Arundel (1585–1646). Now in the British Library (Arundel MS 263) and known by Leonardo scholars as 'Codex Arundel', it is one of the most mechanical of Leonardo manuscripts. Although scholars have looked for a smoking gun, there is as yet no direct evidence that Hooke had read this manuscript of another polymath.

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