Beyond sense and reason
In the last two editorials [Perception 9(6) 613–615, 10(1) 1–4] I discussed the discovery of stereopsis, suggesting that history needs a bit of rewriting, as—although Wheatstone may well have produced the first stereoscopic drawings, presenting one to each eye with his mirror stereoscope—he was not the first to appreciate that depth is given by fusing the slightly different images of the eyes; and he did not invent the first stereoscopic optical instrument. Euclid appreciated that the eyes received different views as a function of relative distances of objects, and so, far more recently, did Leonardo da Vinci; but—although Newton in the 17th century realised (Optiks Query 15) that the optic nerves from the two eyes combine—the notion of visual depth given by disparity is a modern concept. It is not, however, so modern as Wheatstone’s published account of 1838, or the generally accepted date of 1832 of his invention of the stereoscope. In the two previous editorials the discovery of stereo vision and the invention of a stereoscopic optical instrument—a stereomicroscope—was pushed back to Newton’s century: to the stereoscopic compound microscope invented and constructed by a French Capuchin Friar at Orléans—le Père Cherubin—in 1677. In the last editorial I presented an early wood engraving of Cherubin’s 17th century stereo microscope. Let me now consider more general implications of instruments invented at the birth of modern science.

Physics may be, and indeed quite often is, criticised for ignoring the observer and perceptual processes which are essential for knowledge of the physical world—and are part of the nature of things, requiring in their own right explanation. This demoting, even rejection in science of perception, is integral to ‘objective’ knowledge. It is indeed what ‘objective’ means. Among the many unfortunate consequences is the low status of the study of perception since the blinding success of the natural science of Newton, though Newton himself—as also Galileo and other great scientists of the 17th century—was well aware of and wrote eloquently on the mysteries of how we sense the world. By contrast, purely objective accounts are literally senseless. The development of optical instruments which flowered with brilliant inventions in the 17th century had profound effects on how we see perception: some instruments enhance perception while others drastically modify, displace, or even altogether remove the observer. In this, science is entirely different from art.

In ideal physical experiments, if the observer has a role, he is reduced merely to a null indicator. This is so when he uses an instrument as ancient and simple as a straight edge, or a graduated ruler. For measurements of space we are indeed ruled by rulers, which are designed to replace perceived size and distance, by noting coincidences on a scale to give ‘objective’ metrics. This objectivity given by instruments was not challenged until ruler space and universality of clock time were questioned by Einstein and a few of his predecessors such as his teacher, Hermann Minkowski (1864–1909), and G F Fitzgerald (1851–1901). It was also questioned earlier, especially by Newton’s teacher, the saintly Isaac Barrow (1630–1677), who gave up his Cambridge Chair for his genius pupil. Barrow questioned whether clocks record Absolute time (and so whether there is Absolute time) by asking whether there would be time without motion of objects—and which cycling or repeating motions should be accepted as heavenly or earthly clocks. Similarly, Barrow questioned the universality of rulers, for rulers are mere objects and space does not
perhaps depend on objects. So, too, did Newton question; but he came to accept Absolute objective space, as he saw space as God's mind, and us as discovering the Laws of Nature by appreciating with mathematical intuition the idée fixe of God. Newton did, however, allow that God might change His mind; or allow different Laws (or Rules) for different parts, or times, of the Universe. Newton thought of mathematical intuitive knowledge of the rules by which inanimate objects move as our direct awareness of God's mind. Space had to be causal for object motion to be lawful (animals running not on God's Will but on Free Will). Our need for eyes and the other physical senses—he thought—is limited mainly to discovering contingent, and chemical and alchemical properties of objects. This is similar to Plato's view, where rational reality lies behind appearance and measurement. Both for Plato and for Newton, though mathematics gives objective knowledge, perception—even when checked by rulers and clocks or any other instrument—fails to provide universal objectivity. This conclusion is not, however, always accepted. Sir Karl Popper, indeed, calls one of his important books on scientific method *Objective Knowledge* (1972). I shall not argue the case for or against objective knowledge further here.

The other great class of instruments—those which extend the senses to enhance perception in some situations—is characterised by telescope and microscope, both of which came into use at the time of Galileo and Newton. It was, of course, Newton's sad rival Robert Hooke (1635–1703) who wrote the first book of the microscope: *Micrographia* (1665). But this new look at nature was not altogether welcome, and was indeed distrusted by the father of scientific method, Francis Bacon (1561–1626), on whose ideas the Royal Society of London was founded in 1660, and given its Royal Charter two years later. In his *Novum Organum* (1620) Bacon castigates the Greeks, and especially Aristotle, for relying too much on argument and intuition and too little on observation; but, most curiously, he also knocks—while admitting they enhance perception—the newly-invented telescope and microscope. These 'aids to the senses' Bacon discusses under the heads "Instances of the Lamp" or "of First Information" (*Novum Organum* Book 2 Aphorism XXXVIII); and in the next Aphorism, "Instances of the Door or Gate, this being the name I give to instances which aid the immediate actions of the senses". Here he complains that the microscope is "only available for minute objects. So if Democritus had seen one he would perhaps have leapt for joy, thinking a way was now discovered of discerning the atom, which he had declared to be altogether invisible." Bacon continues: "The Incompetency however of such glasses, except for minutiae alone, and even for them when existing in a body of considerable size, destroys the use of the invention. For if it could be extended to larger bodies or to the minutiae of larger bodies, so that the texture of a linen cloth could be seen like a net-work, and thus the latent minutiae and inequalities of gems, liquors, urine, blood, wounds, etc, could be distinguished, great advantages might doubtless be derived from the discovery."

Similarly for the telescope, and in the face of the recently reported epoch-making observational discoveries of Galileo, Bacon (Aphorism XXXIX) admits that Galileo's telescope "show(s) us that the Milky Way is a group or cluster of small stars entirely separate and distinct", and that "with this instrument we can descry those small stars wheeling as in a dance round the planet Jupiter, whence it may be conjectured that there are several centres of motion among the stars". Yet, in spite of these and other supremely dramatic demonstrations of the power of visual perception enhanced by lenses, Bacon concludes: "I regard (them) with suspicion chiefly because the experiment stops with these few discoveries and many things equally worthy of investigation are not discovered by the same means."

Bacon's complaint is not that there are artifacts, though Galileo's observations were challenged, as it was well known that the curved glass panes of shop windows of
that time distorted the goods displayed. It was indeed the Merchants of Venice, correctly recognising with telescopes their ships at otherwise impossible distances, that validated Galileo's astronomical observations—first in their eyes and then to science. In spite of this—and he mentions the Merchants' use of telescopes—that most shrewd man Francis Bacon remained suspicious, because the observations did not lead or he could not see them leading to further experiments. Possibly if this had remained true we would have inherited, and still retain, his suspicion of enhanced perception—indeed of all perception in science.

The deep trouble, as Plato recognised, is that perceptions are of particular instances while knowledge is generalisation. This so impressed Plato that he denied that perception provides any knowledge; the most it can do being to remind us of what we already know. Nevertheless, as Plato makes Socrates say in the *Meno*: "We shall be better, braver and more active men if we believe it right to look for what we don't know than if we believe there is no point in looking because we don't know we can never discover." Plato compares knowledge (in the *Protagoras*) with goods in shops: "When you buy food and drink you can carry it away from the shop or warehouse in a receptacle .... But knowledge cannot be taken away in a parcel." He continues: "When you have paid for it you must receive it straight into the soul: you go away having learned it and are benefitted or harmed accordingly."

The point is that the perception-enhancing instruments of the 17th century finally ousted Plato's and the entire tradition of Rationalism, that had such vast inertia it stopped even the champion of experimental method Francis Bacon from accepting the power of instruments to enhance, or match, the senses to the very small or near and the very large or distant. But microscopes and telescopes did not only reveal features of the world beyond Sense and Reason: they showed that sensory perceptions can be unreasonable and yet true.

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