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History of optics

John Elliot MD (1747–1787)

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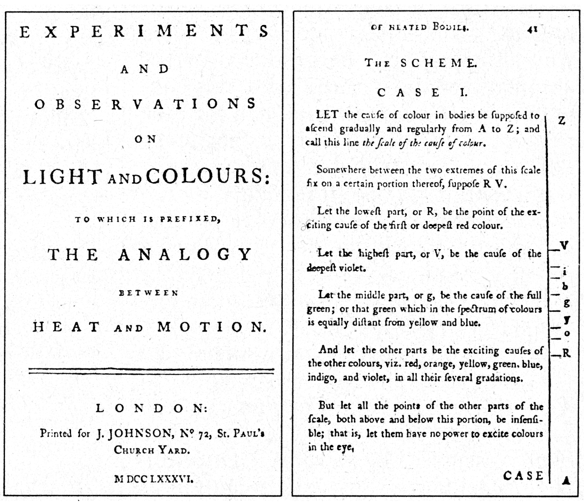
The unfortunate Mr. Elliot is a character on whom every eye should be directed with charity: — he is one of the first geniuses this or any other country ever produced.

SUCH was the judgement of *The Daily Universal Register* (later to become *The Times*)[1]; and for a few brief weeks in the summer of 1787, the name of John Elliot, MD, was known to every newspaper reader. His trial is sometimes recalled in anthologies of crime[2], but by historians of science he has been largely neglected[3] or else confounded with his contemporary, Sir John Eliot, Bart (1736–1786)[4]. Two hundred years after his death it is interesting to examine how his experiments in physiological optics led him to fundaental insights in physical optics.

At the age of fourteen, we are told[5–7], Elliot was bound apprentice to an apothecary in Spitalfields, and at the expiry of his time he joined a large practice in Cheapside. It was during this period that he established a romantic attachment to Miss Mary Boydell, niece of the celebrated Alderman Boydell. At first, if we are to believe Elliot's own account[7], Miss Boydell encouraged him but later she rejected him, whereupon he left London. By 1780, however, Elliot had returned and set up in business in Carnaby market. In that year he published his *Philosophical Observations on the Senses*[8], which anticipates Johannes Müller's *Doctrine of Specific Nerve Energies*[9] and was known to Müller in translation[10].

To understand Elliot's insights into sensory physiology, recall that most eighteenth-century writers supposed that vibrations of the aether or of the air were directly communicated to the optic and auditory nerves and were faithfully transmitted to the sensorium, the place where sensations were aroused (see refs 11, 12). What was lacking was the concept of a transducer, a sensory receptor tuned to only a limited part of the range of physical frequencies. It can be argued that this inadequate physiological model held back the understanding of physical optics in at least two ways: first, few suspected the existence of infrared and ultraviolet radiation, radiation for which we have no transducers; and second, many physicists, knowing that most colours could be produced by mixing three, believed that there were only three kinds of light[13].

In a series of masochistic experiments, Elliot showed that mechanical stimulation of the eye or the ear could produce a variety of specific sensations, the sensation being always appropriate to the modality stimulated. He rightly concluded that there must be transducers in our sense organs, different ones for the different frequencies — or to use his words[8], that



EXPERIMENTS

AND

OBSERVATIONS

ON

LIGHT AND COLOURS:

TO WHICH IS PREFIXED,

THE ANALOGY

BETWEEN

HEAT AND MOTION.

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OF HEATED BODIES. 41

THE SCHEME.

CASE I.

LET the cauſe of colour in bodies be ſuppoſed to aſcend gradually and regularly from A to Z; and call this line *the ſcale of the cauſe of colour.*

Somewhere between the two extremes of this ſcale fix on a certain portion thereof, ſuppoſe R V.

Let the loweſt part, or R, be the point of the exciting cauſe of the firſt or deepeſt red colour.

Let the higheſt part, or V, be the cauſe of the deepeſt violet.

Let the middle part, or g, be the cauſe of the full green; or that green which in the ſpectrum of colours is equally diſtant from yellow and blue.

And let the other parts be the exciting cauſes of the other colours, viz. red, orange, yellow, green, blue, indigo, and violet, in all their ſeveral gradations.

But let all the points of the other parts of the ſcale, both above and below this portion, be inſenſible; that is, let them have no power to excite colours in the eye,

Z V i b g y o R A

CASE

Fig. 1 Title page (left) and text (right) from a monograph of 1786 in which Elliot makes explicit the possibility of optical radiation beyond the limits of the visible spectrum. (Reproduced by permission of Edinburgh University Library).

Fig. 2 A sketch (by Ozias Humphry, RA) entitled *Youth* and thought to be a portrait of Miss Mary Boydell.

. . . there are in the retina different times of vibration liable to be excited, answerable to the time of vibration of different sorts of rays. That any one sort of rays, falling on the eye, excite those vibrations, and those only which are in unison with them . . . And that in a mixture of several sorts of rays, falling on the eye, each sort excites only its unison vibrations, whence the proper compound colour results from a mixture of the whole.

Two years later[14] he elaborates:

We are therefore perhaps to consider each of these vibrations, or colours in the retina, as connected with a fibril of the optic nerve. That the vibration being excited, the pulses thereof are communicated to the nervous fibril, and by that conveyed to the sensory, or mind, where it occasions, by its action, the respective colour to be perceived.

Elliot nowhere says that there are only three retinal resonators and so he never took the small, final step to understanding why all colours can be produced by trichromatic mixture. Conversely, his contemporary, George Palmer, had the idea of three receptors[15,16], but did not grasp that the physical variable underlying hue was a continuous one. It remained for the two hypotheses — physiological trichromacy and continuous variation in physical frequency — to be put together by Thomas Young, who was certainly familiar with Elliot's ideas[17].

But Elliot's physiological model did lead him to a physical insight equal to Young's insight into trichromacy. The relationship between light and heat had been discussed by several eighteenth-century authors, but James Hutton is often held to be the first clearly to suggest (in 1794) that there might exist radiation of low refrangibility that had the power of heating but had little power of exciting the organ of sight[18]. William Herschel's empirical study[19] of the infrared, published in 1800, is well known.

In fact, the concepts of the infrared and ultraviolet were introduced explicitly in 1786 in an anonymous work entitled *Experiments and Observations on Light and Colours* (Fig. 1). From internal evidence, and from a manuscript rejected, but preserved, by the Royal Society[7] we can be sure that the author was John Elliot. Down the side of one page, Elliot draws what may be the first representation of a spectrum extended in both directions beyond the visible region (Fig. 1). His text develops an elaborate analogy between heat and motion, and introduces something very close to the concept of colour temperature:

> If the cause of colour be supposed to be simple (*for example, if it is supposed to consist in vibration, which may be increased in swiftness, or quickness of return*) and to ascend uniformly from A [see Fig. 1], it will be invisible till it arrives at the lowest part of the assumed portion, or R . . . It will then begin to become sensible under the form of the deepest red colour. This colour will continually vary, passing gradually . . . through all the degrees of red, orange, yellow, green, blue, indigo and violet . . . In the light emitted by shining bodies, some colours abound more than others; but the inequality is regular; and the predominant colour varies with the heat according to the foregoing law.

Elliot himself makes explicit the relationship between his earlier physiological model and his physical insights:

> . . . He ['a writer on this subject'] therefore suggests that the rays of light excite colours in us only by the mediation of these internal colours. From whence it would follow, that if there are rays of light which have no answerable colours in the eye, those rays cannot be visible . . .

Elliot grasped, as Herschel later did not[20], that the difference between visible and invisible radiation lies in the spectral sensitivity of our eye and that the two forms of radiation are not qualitatively distinct.

Elliot also deserves a place in the early history of spectroscopy. In simple experiments, he observed heated bodies by means of a small aperture and prism:

> As the body in the third experiment cooled, it was pleasant to observe how, by degrees, the violet first, and then the indigo, blue, and the other inferior colours vanished in succession, as if the spectrum were contracting itself towards its inferior part; and how the centre of the range seemed gradually to move from orange to red, and at length beneath it, as if it sunk into the insensible part below R in the scheme, the superior part following it, till the whole range was out of sight . . .

But Elliot's scientific career was ending. Into his shop one day came Mary Boydell with a lady companion. Thereupon, by Elliot's account[6], both he and Miss Boydell swooned. Their relationship was re-established, but Miss Boydell soon rejected Elliot again, and he was once more consumed by bitter melancholy. He bought two brace of pistols. One brace — or so his attorney claimed at the trial — he filled with shot, and the other with blank shot, his intention being to discharge the blank shot at Miss Boydell and then shoot himself dead at her feet[21]. On 6 July 1787, near Leicester Square, Elliot came up behind Miss Boydell, arm in arm with her companion, Mr Nichol. Elliot fired at Miss Boydell, but before he could shoot himself he was seized by Nichol.

At his trial at the Old Bailey, the prosecution insisted that the pistols had been loaded — and that Miss Boydell had been saved only by her whalebone stays. Her scorched dress was produced in court (*The World, Fashionable Advertiser* for 17 July tells us it was "of very elegant white muslin, spangled with gold"). The defence claimed that the pistols had not been loaded; and that in any case Elliot was of unsound mind. Some of his scientific writings were adduced as proof of his insanity. The jury acquitted him, but the Recorder committed him to Newgate nevertheless, to be tried for assault. Elliot entered on a hunger strike and was dead by 22 July. The *Daily Universal Register*, ever on his side, held that he died "of what is commonly stiled a broken heart". ☐

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