V. A new theory of telescopes founded on rational principles and interesting experiments

J. Reade M.D.

To cite this article: J. Reade M.D. (1824) V. A new theory of telescopes founded on rational principles and interesting experiments , Philosophical Magazine Series 1, 63:309, 20-30, DOI: [10.1080/14786442408644458](https://doi.org/10.1080/14786442408644458)

To link to this article: <http://dx.doi.org/10.1080/14786442408644458>

Published online: 29 Jul 2009.

Submit your article to this journal [↗](#)

Article views: 4

View related articles [↗](#)

V. *A new Theory of Telescopes founded on rational Principles and interesting Experiments.* By J. READE, M.D.*

LOOKING on the corneal theory of vision as established, in this paper I shall endeavour to apply that theory to practical advantage in the science of astronomy. Although I have shown, by numerous and I may venture to say conclusive experiments, that our ideas of objects are produced by erect images painted on the pupil, still I by no means argue that the retina is not the nerve communicating with the sensorium, in a similar manner as the nerves minister to feeling, hearing, tasting and smelling. Indeed, the five senses may be all reduced to one, the sense of feeling. So long as philosophers believed that inverted images painted on the retina produced the phænomena of vision, so long the most inconsistent opinions were advanced of long- and short-sightedness, and the theory of telescopes, spectacles, &c. "If the cornea or crystalline (say authors), or either of these, be too flat, a pencil of light coming from an object at an ordinary distance will have its focus at some point beyond the retina, and therefore vision will be indistinct, as in the case of an object too near for a common eye." Let us for a moment examine this reasoning. It is admitted on all hands, that no inverted image is ever formed, until the rays cross after arriving at the focus; consequently, if the focal point were situate beyond the retina, no image could ever be painted on that substance, and we must be driven to the absurdity, that the mind could perceive an object without an image. Dr. Porterfield has some strange metaphysical ideas on this subject, at one time talking of pictures on the retina, and the next moment denying their existence. Having examined the eyes of many short-sighted persons with much accuracy, I find them not to differ in the least from long-sighted eyes; hence the flatness or plumpness of the cornea can have nothing to do with the disease, however necessary it may be to the refracted theory of philosophers.

Here I may enlarge on this subject, but must refer to a former paper in your valuable Journal†, wherein I have experimentally demonstrated that focal images are not formed by any crossing of the rays, when passed through a lens, but that the focus is produced by reflected images uniting, and sent from the concave sides. Indeed, I am inclined to think that we must look to the nerves for the cause of short-sightedness, and not to any fanciful flatness or plumpness of

* Communicated by the Author.

† See Phil. Mag. vol. lviii. p. 249, and vol. lix. p. 200.

the cornea. For on an analogy with the other senses, such as feeling, hearing, tasting, &c., we find extreme stimuli act so as for a time to injure the organ, and in a manner to paralyse sensibility. Thus a soldier returning from the field of battle, and deafened by the roar of cannon, for a time becomes insensible to minor sounds. The fingers accustomed to rough usage, are incapable of nice works; and in like manner the retina accustomed to the stimulus of light sent from very close objects, by degrees adapts itself and becomes insensible to those more remote, and consequently less powerful. On similar principles, a person with the best sight may make himself short-sighted, by merely wearing concave glasses. I have met with some simple young gentlemen at College, who produced the disease by this affectation, and became perfectly short-sighted. It is well known that watch-makers are short-sighted, and sailors the reverse. A long-sighted person may become short-sighted in a week, or after a fever, or a nervous disease, without any change of the cornea or crystalline lens. Nor can I conceive that wearing a concave glass could after any time change the shape of the cornea.

For the purpose of particularly investigating this subject, I requested a very short-sighted gentleman to seat himself opposite the letter T pasted on the window, as already mentioned in my paper *On Vision*, published in the *Annals of Philosophy*; and on looking at the correct reflected image on the pupil, and comparing it with that of a long-sighted person seated at the same distance, I could not perceive the least difference either in the size or strength of colouring; yet the long-sighted gentleman saw the letter distinctly, while the other said that he only saw a very confused and large outline. Hence we must infer that the disease lies not in any plumpness or flatness of the cornea, but in either the humours or the nerves, or both. A convex glass increases the confusion with a short-sighted person, and therefore is never used; with a long-sighted person it renders the object more distinct. By the interposition of a concavo-concave glass, an image is formed very near the eye, which, although small, sends the rays with as much force to the cornea, as if the object itself were in the same place: short-sighted people choose a small print, write a small hand, and take off their spectacles when reading. Much has been written to very little purpose on the means of finding the foci of spectacles, and philosophers have exerted all their ingenuity; yet the practical optician, however qualified to read their learned essays, throws them aside for the old-fashioned and purely mechanical method of holding the lens before a wall, and measuring the focus with
a rule:

a rule: yet it must be allowed that on a subject of such importance to the happiness of mankind, such a method is very unsatisfactory, and often leading to an injury of sight, for two convex or concave spectacle glasses may be very dissimilar in transparency or quality of glass without in the least affecting the focal images; this may be shown by scratching a lens or soiling the surface without in the least altering those focal images. The following method, arising out of the discovery that the cornea is the true seat of vision, is preferable. Procure two glass globes somewhat larger than the human eye, fill them with pure water, and place them in a case at about one inch from each other to represent the human eyes. The glasses for examination, whether convex or concave, should now be placed in their frames and held in front of these globes, and before the letter T pasted on the window. On comparing the magnified or diminished images of the letter on the convex faces of these globes, the practical optician may immediately say whether they are similar in their powers, whether they magnify or diminish equally, and likewise whether the images are clear and distinct. In making this experiment, we should take care to have the globes perfectly similar. Hereafter I shall resume this subject, and shall now proceed to the theory of telescopes.

As the Galilean telescope is the most ancient, most simple, and most generally used, I shall begin with it. For a good history of this instrument I must refer to an excellent article in Brewster and Rees's *Encyclopædias*, and in a concise manner shall give the present theory from Mr. Wood's *Elements of Optics*, one of the best works I have seen on the subject, and I am informed the one used at Cambridge, perhaps the first mathematical university in Europe. "Galileo's telescope consists of a convex object-glass, and a concave eye-glass, whose axes are in the same line, and whose distance is equal to the distance of their focal lengths. A distant object may be seen distinctly through Galileo's telescope, and the angle which it subtends at the centre of the eye when thus seen, is to the angle which it subtends at the centre of the naked eye as the focal length of the object-glass to the focal length of the eye-glass.

"Let L and E be the centres of the glasses, PQR a distant object towards which the axis of the telescope is directed; pqr its images in the principal focus of the glass L, and therefore in the principal focus of the glass E.

Then since the rays tend to form an image in the principal focus of the concave lens E, after refraction at that lens they will be proper for vision, or a distinct image of the object

PQR

PQR will be formed upon the retina of a common eye.

Also, the angle under which the object QP is seen through the telescope is equal to the angle $q'Ep'$; and the angle under which it is seen by the naked eye at L is QLP , which is equal to $q'Ep'$. Therefore the visual angle in the former case : the visual angle in the latter :: $Lq : Ep'$. From this reasoning Mr. Wood infers the corollary that the magnifying power of the Galilean telescope is measured by $\frac{Lq}{Ep'}$.

Before I enter on a mathematical examination, I shall beg leave to call the attention of my readers to what I conceive to be a metaphysical absurdity attending this theory: I shall quote a passage from Dr. Young, an able mathematician and experimental philosopher; who says in his *Lectures on Natural Philosophy*, p. 428, "In the Galilean telescope or opera-glass, a concave eye-glass is placed so near the object-glass that the first image would be formed beyond it and near its principal focus, and the second image formed by the eye-glass, which is the vertical image viewed by the eye, being on the opposite side of the centre, is inverted with respect to the first image, and erect with respect to the object." And in page 427, he continues, that "in almost all telescopes and compound microscopes the image formed by one lens or mirror stands in the place of a new object for another. The operation of such instruments may be illustrated (say Dr. Young and other authors) by placing a screen of fine gauze in the place of the image, which receives enough of light to make the image visible in all directions, and yet transmits enough to form the subsequent image."

Here let us pause, and mark the gross metaphysical absurdity, in supposing that an inverted image painted on the retina could enable the observer to see both an erect object through the telescope, and an inverted object or image at the piece of gauze. Again: Dr. Young supposes that this inverted image at the gauze transmits enough of rays to form the subsequent image on the retina. Now it is evident this retinal image would be erect in respect to the image on the gauze,

gauze, and therefore the observer should see it inverted: but why see the object erect? I am inclined to hope that Dr. Young will agree with me, not only that this experiment and reasoning involve a metaphysical absurdity, but that they strike at the retinal theory of vision. For to perceive an object both erect and at the same time inverted, by means of one image on the retina, is impossible. But there is no difficulty with respect to the corneal theory of vision; for on holding a concave and convex glass before the eye of an observer looking at the letter on the window, I distinctly perceived a small erect image of the letter on the pupil, and likewise an inverted image produced by the refracted rays as they are called. 2dly, The eye of the observer is always placed close to the eye-glass. If the magnitude of the object seen through the telescope depended on the visual angle qEp , the object should appear larger the further the eye was removed from the eye-glass; but direct experiment teaches that the contrary is the fact. Indeed, the idea of an inverted image floating in the air, invisible, yet visible, and measured by a visual angle beyond the influence of the nerves, which visual angles are measured by the calf as well as the cow, by the idiot as well as the philosopher, is more than we can believe: even the learned Berkeley, late bishop of Cloyne, who advanced many strange things, could not believe in this. The next object is, that these focal and vertical images, from which our ideas are supposed to be derived, are ten or twenty times as large as the area of the pupil itself, and consequently a conjurer may as well get into a quart bottle as these images through the pupil. This is a strong objection, and I conceive an insurmountable one, to the present theory of telescopes. Indeed I am surprised it should have escaped notice. How is it possible that the extreme rays coming from a vertical image one inch or more in length and half an inch in breadth, could not only enter the pupil, but a hole the size of a pin's head, such as that used by surveyors? We must either admit, what opticians do not allow, that rays converge after passing through the concave eye-glass so as to form a very sharp cone at the pupil, and do away with the magnifying power, illustrated by the angle qEp , otherwise the cone would be at the wrong end. Having unscrewed the eye-glass of an opera telescope about three inches long, I held it before the window, and, on placing a card at the principal focus, found that focus to be about five inches from the object-glass. The letter T on the window, being ten feet distant when the eye-glass was again screwed on, the focal image became somewhat enlarged, but very indistinct. What I principally wish to impress is the fact,

fact, the incontrovertible fact, that this focal image when intercepted by the card was nearly two inches in breadth, and yet the pupil through which they were to pass was not 1-4th of an inch, nor the eye-hole of the telescope 1-20th of an inch. And, as already mentioned, if $q E p$ measured the magnifying power, the further the eye was removed from the eye-glass the larger the object should appear: that the reverse is the fact must be known to every experimenter; indeed at a little distance the extreme rays coming from Q and P and crossing at L and then diverging, would not only clear the pupil itself, but the very ears of the spectator; consequently to argue that we see the object by means of these rays, is absurd.

The fourth objection I have to bring forward is, that focal images are always painted immediately in the axis of the lens, and no where else. Therefore, if these inverted images were the cause of vision, the pupil of the observer's eye should be always placed in the axis of the lens, and no where else. However, direct experiment informs us that we can see through a refracting telescope, when the eye is removed considerably to the right or left of the axis. Indeed I have been enabled to see the inverted image of an object painted on the bull's eye, when my pupil was at right angles with the axis, where it was impossible that any of these rays could enter the eye.

Having thus shown, I hope to the satisfaction of my readers, that this mathematical theory of the Galilean telescope is fallacious, I shall now endeavour to substitute a more rational theory, and one founded on direct experiment. I must refer to my former paper on Vision for those experiments which prove that rays diverge in passing through a convex lens, and converge in passing through a concave one. I have also shown in a former paper that rays never form focal images by crossing, which forms another strong objection. Having procured a convexo-convex lens, whose focus was about two feet, and a concavo-concave lens for an eye-glass, Number 17, I covered half the concave lens or eye-glass with a piece of white paper. I now held these two lenses opposite a lighted candle so as to form a telescope without the tube, and on removing the object-glass to the proper distance from the eye-glass, I perceived the candle erect and considerably magnified in all its dimensions; and I also perceived an inverted image of the candle, painted on the paper of the eye-glass. Here I again assert, that it would be metaphysically absurd to say that rays coming from this inverted image produced both the sensation of an erect and at the same time of an inverted image.

The following conclusive experiment will explain the true theory of the Galilean telescope. Having placed a glass globe filled with water in a wine glass resting on a table; immediately opposite the letter T on the window, the letter was distinctly painted by refraction on the convex surface. I now held the convex object-glass already described at about a foot and half distance over this image, and perceived it to be considerably magnified, and surrounded with confused colours. I now interposed the concave eye-glass at about one inch before the image, and perceived the image to be diminished to nearly half its size; but the colours at the margin vanished, and it became, although smaller, much more distinct and black. This image could be either increased or diminished by approaching or distancing the object-glass. I now pasted a piece of white paper on the globe in the vicinity of the reflected image, and could perceive that the rays which went to form the inverted virtual image, as it has been named, had nothing to do with the erect image formed on the convex side of the globe by reflection. From this experiment, and numerous others, I would infer that in the Galilean telescope the eye-glass diminishes the image formed on the pupil by the object-glass; so that a small well-defined image is painted close to the pupil, which standing in place of the object, and magnified by the object-glass to the proper standard of distinct vision, I now made an assistant seat himself opposite this letter on the window; and on holding the glasses in the same manner before his pupil, I perceived similar effects; and when the white paper was pasted on half the eye-glass, on his looking at the letter, I perceived the erect image in the pupil, and the inverted image painted on the paper at the eye-glass. I now instead of the white paper put on a piece of white cloth, so as to hinder those rays from going at all to his eye; yet he perceived the object through the telescope. After this experiment, can any person contend that this virtual image is the mean of vision through the telescope? The field of view in the Galilean telescope depends on the distance of the object-glass, for the size of the image is inversely as the distance.

Thus having shown by numerous experiments that these gross refracted rays, with all their twistings and turnings, have nothing to do with the phænomenon of vision either naked or armed with the telescope, further than by throwing a quantity of light into the pupil, I shall now give a figure.

a, the letter T pasted on the window, sends an image to the object-glass B C, where two more images are formed in each

each surface : hence they are sent magnified to the eye-glass DE, which again transmits the image to the eye F ; thence

to the retina, and finally to the sensorium. This is a correct outline of the Galilean telescope, supported in every stage by direct experiment. I have particularized Dr. Young's opinions, both because that gentleman is justly celebrated in the scientific world, and because I preferred the living to the dead. The pleasure I feel at having discovered the corneal theory of vision, is somewhat diminished by considering that it strikes at some of the most interesting theories in astronomy. For if the theory of refraction be proved fallacious, it follows as a consequence, that the greatest astronomers have no idea of the distances of the planets, &c., all their calculations being built on visual angles and virtual images.

On looking over the Philosophical Transactions for 1821, I find a paper written by a very intelligent experimenter, Mr. J. F. Herschel, On the Aberrations of Compound Lenses and Object-glasses. This gentleman,—seemingly unacquainted with the experiments I have published some years ago, both in your Journal and in the Experimental Outlines,—after remarking on Euler and Dalember, from whose exertions he says nothing resulted beyond a mass of complicated formulæ, he gives a number of algebraic calculations, entirely built on the gratuitous assumption that Newton really separated the whole light into seven coloured rays. Was Mr. Herschel unacquainted with my experiments? If so, I would beg leave to call his attention to the following.

If a square piece of black cloth with a small semicircular piece cut from the lower part in the following manner, be pasted on a pane of glass at the window, on looking at it through the lower refracting angle of the prism, we perceive the bottom to be fringed with red and yellow rays ; if we now paste another similar piece some little distance below it on the same pane, and in an inverted position, as thus represented we perceive, on looking through the prism, the upper part to be fringed with blue and violet : thus we have three simple and one compound colour produced by these fringes, derived from the black light reflected

from these two pieces of cloth, and rarefied by sticking on the pane. The violet is evidently compounded of the orange blending with the black light of the lower piece of cloth, and the reader is to notice that when these two pieces are kept asunder, we never perceive more than four colours,—blue, red, yellow and violet: but if we now direct an assistant to approximate the pieces, the yellow fringe of the upper one immediately passes over the blue fringe of the lower piece, and forms a vivid green; and until this takes place, no green is ever formed. The *rationale* of this interesting experiment is too obvious to require much observation. The square piece of black cloth represents the dark window-shutter of Sir Isaac Newton's experiment; and the two semicircular cuts, when united, represent the circular hole through which the sunbeams passed. The black light reflected from the edges of the hole was rarefied by striking the plane of the prism into colours, and mixing gave the spectrum of seven colours to the eye.

Here we have to remark, that the light passing through the centre of this hole was colourless, not mixing with the fringes, entirely produced by rarefied black light, as is easily shown by passing the shadow of a knitting-needle through a prism placed in the sunbeams. Here we are also to remark, that the green is formed after emergence by a mixture of the blue and yellow, and by no means a simple colour as Newton supposed. Thus did Sir Isaac Newton compound what he calls seven with the three simple and primary colours,—blue, red, and yellow. I am fully confident that no unprejudiced person, after repeating this easy experiment, can for one moment doubt that this great philosopher was entirely mistaken in his inference; and however we may admire the ingenuity of that reasoning, which for centuries could make the world believe that transparent light was a compound of opaque rays, yet we cannot extend our approbation to those gentlemen, however learned or respectable, who in the face of direct experiment, and I will venture to say common sense, continue to uphold false principles. If the experiments I have published can be refuted, I am ready to give them up and acknowledge myself in error; if not, I call on those gentlemen to act with candour and liberality.

I now varied this experiment in the following manner: I allowed the sunbeams to pass through the hole, and placing a prism behind it, so as to pass them through the lower refracting angle, I perceived a beautiful oblong spectrum of the hole, not the sun, on the opposite wall: that this spectrum was oblong and not circular, by no means surprised me, as I had already

readily remarked, that the straight shadow of a knitting-needle became curved by striking and passing through the prism; consequently a circle would become oblong: but what at first did surprise me was, that the entire colours of the spectrum were reversed from what I saw on looking at the hole through the prism. The violet was now at top, the orange at the bottom. This fact escaped the notice of Newton and his followers: had they noticed it, the theory of repulsion and attraction must have undergone some slight modification. At some future time I shall endeavour to account for this phænomenon. And I again repeat, that any person performing this experiment must be satisfied that the colours are produced by those fringes, and also that those fringes are produced by the rarefaction of black light, and by no means from any separation of the solar ray.

I shall now say a few words on the astronomical telescope. Mr. Woods has the following description, p. 160:—

“ Let L and E be the centres of the two glasses; $Q P$ an

object towards which the axis of the telescope is directed, and so distant that the rays which flow from any one point in it, and fall upon the object-glass L , may be considered as parallel. Then qp , an inverted image of $Q P$, will be formed in the principal focus of the glass L , and contained between the lines QLq and PLp ; and because LE is equal to the sum of the focal lengths of the two glasses, $p q$ is in the principal focus of the glass AB ; consequently $p Q$ may be seen distinctly through the glass, if the eye of the observer be able to collect parallel rays upon the retina. Produce pL till it meet in the eye-glass in B , join $p E$, and draw BO parallel to $p E$. Then the rays which flow from p in the object on p its image, enter the eye placed at O in the direction BO ; also the rays which flow from Q enter the eye in the direction EO . Thus the angle which $Q P$ subtends at the centre of the eye, when viewed through the telescope, is the angle $Bo E$, which is equal to $PE q$. The angle which $Q P$ subtends when viewed with the naked eye from L , is $PL Q$, which is equal to $p L q$." The same objections I have already brought against the Galilean telescope are equally strong here; I therefore

fore shall merely give a figure of what I conceive to be the true theory of this instrument.

a, the letter *T* pasted on the window, sends an image to the

convex object-glass, which is too much rarefied to pass to the eye, but two inverted images are formed at *b* and *c*, which uniting at the eye-glass *CD*, form one inverted image *d*. This again is magnified and sent to the eye at *E*, whence it travels to the retina and sensorium. In both telescopes the image at the eye-glass stands in place of an object.

As this paper is intended as a mere outline, I have not given the exact foci of the glasses, choosing those of high powers. The experimenter is to distinguish between the converging rays and those which form the image. Let him make the following experiment:—Place the glass globe filled with water in the sunbeams, and holding a convex lens over it, he perceives an image of the lens with the sun painted on the convex surface, and he also perceives the gross refracted rays form an image of the sun which can be thrown to some distance, having nothing whatsoever to do with vision. This I proved by the following experiment: I desired a friend to look at a lighted candle, and holding a convex lens opposite his pupil, I perceived the lens with a magnified image of the candle to be painted on his pupil, while by holding the lens a little obliquely, I threw the refracted rays on the side of his nose or on his forehead.

I remain your obedient servant,

Cork, April 22, 1823.

JOSEPH READE, M.D.

VI. *Description of certain Gangues of Spinnelle brought from the Island of Ceylon by M. LESCHENAULT DE LATOUR. By M. le Comte de BOURNON, Chev. de St. Louis, F.R.S. &c.**

IN a memoir on Corundum which I presented to the Royal Society of London, and which has been printed in the Philosophical Transactions for 1802, after having fulfilled the

* Extracted from *Observations sur quelques-uns des Minéraux, soit de l'Ile de Ceylon, soit de la Côte de Coromandel, rapportés par M. LESCHENAULT DE LATOUR. Par M. LE COMTE DE BOURNON. PARIS. 1823.*

end