AN ESSAY TOWARDS A NEW THEORY OF VISION

I. My design is to show the manner wherein we perceive by sight, the distance, magnitude, and situation of *objects*. Also to consider the difference there is betwixt the *ideas* of sight and touch, and whether there be any *idea* common to both senses. In treating of all which, it seems to me, the writers of optics have proceeded on wrong principles.

II. It is, I think, agreed by all, that *distance* of itself, and immediately, cannot be seen. For *distance* being a line directed end-wise to the eye, it projects only one point in the fund of the eye. Which point remains invariably the same, whether the distance be longer or shorter.

III. I find it also acknowledged, that the estimate we make of the distance of *objects* considerably remote, is rather an act of judgment grounded on *experience* than of *sense*. For example, when I perceive a great number of intermediate *objects*, such as houses, fields, rivers, and the like, which I have experienced to take up a considerable space; I thence form a judgment or conclusion, that the *object* I see beyond them is at a great distance. Again, when an *object* appears faint and small, which, at a near distance, I have experienced to make a vigorous and large appearance; I instantly conclude it to be far off. And this, it is evident, is the result of *experience*; without which, from the faintness and littleness, I should not have inferred any thing concerning the distance of *objects*.

IV. But when an *object* is placed at so near a distance,

as that the interval between the eyes bears any sensible proportion to it, it is the received opinion that the two *optic axes* (the fancy that we see only with one eye at once being exploded) concurring at the *object*, do there make an *angle*, by means of which, according as it is greater or lesser, the *object* is perceived to be nearer or further off.

V. Betwixt which, and the foregoing manner of estimating distance, there is this remarkable difference. That whereas there was no apparent, necessary connexion between small distance and a large and strong appearance, or between great distance, and a little and faint appearance. Yet there appears a very necessary connexion between an obtuse angle and near distance, and an acute angle and further distance. It does not in the least depend upon experience, but may be evidently known by any one before he had experienced it, that the nearer the concurrence of the *optic axes*, the greater the *angle*, and the remoter their concurrence is, the lesser will be the *angle* comprehended by them.

VI. There is another way, mentioned by the optic writers, whereby they will have us judge of those distances, in respect of which, the breadth of the *pupil* hath any sensible bigness. And that is the greater or lesser divergency of the rays, which, issuing from the visible point, do fall on the *pupil:* that point being judged nearest, which is seen by most diverging rays; and that remoter, which is seen by less diverging rays. And so on, the apparent distance still increasing, as the divergency of the rays decreases, till at length it becomes infinite, when the rays that fall on the *pupil* are to sense parallel. And after this manner it is said we perceive distances when we look only with one eye.

VII. In this case also, it is plain we are not beholding to experience: it being a certain, necessary truth, that the nearer the direct rays falling on the eye approach to a *parallelism*, the further off is the point of their intersection, or the visible point from whence they flow.

VIII. I have here set down the common, current accounts that are given of our perceiving near distances

by sight, which, though they are unquestionably received for true by *mathematicians*, and accordingly made use of by them in determining the apparent places of *objects*, do, nevertheless, seem to me very unsatisfactory: and that for these following reasons:—

IX. *First*, It is evident that when the mind perceives any *idea*, not immediately and of itself, it must be by the means of some other *idea*. Thus, for instance, the passions which are in the mind of another, are of themselves to me invisible. I may nevertheless perceive them by sight, though not immediately, yet by means of the colours they produce in the countenance. We do often see shame or fear in the looks of a man, by perceiving the changes of his countenance to red or pale.

X. Moreover it is evident, that no *idea* which is not itself perceived, can be to me the means of perceiving any other *idea*. If I do not perceive the redness or paleness of a man's face themselves, it is impossible I should perceive by them the passions which are in his mind.

XI. Now from Sect. II., it is plain that distance is in its own nature imperceivable, and yet it is perceived by sight. It remains, therefore, that it be brought into view by means of some other *idea* that is itself immediately perceived in the act of *vision*.

XII. But those *lines* and *angles*, by means whereof *mathematicians* pretend to explain the perception of distance, are themselves not at all perceived, nor are they, in truth, ever thought of by those unskilful in optics. I appeal to any one's experience, whether, upon sight of an *object*, he compute its distance by the bigness of the *angle* made by the meeting of the two *optic axes?* Or whether he ever think of the greater or lesser divergency of the rays, which arrive from any point to his *pupil?* Nay, whether it be not perfectly impossible for him to perceive by sense the various angles wherewith the rays, according to their greater or lesser divergence, do fall on his eye. Every one is himself the best judge of what he perceives, and what not. In vain shall all the *mathematicians* in the world tell me, that I perceive

certain *lines* and *angles* which introduce into my mind the various *ideas* of *distance;* so long as I myself am conscious of no such thing.

XIII. Since, therefore, those *angles* and *lines* are not themselves perceived by sight, it follows from Sect. x., that the mind does not by them judge of the distance of *objects*.

XIV. Secondly, the truth of this assertion will be yet further evident to any one that considers those *lines* and *angles* have no real existence in nature, being only an *hypothesis* framed by *mathematicians*, and by them introduced into *optics*, that they might treat of that science in a *geometrical* way.

XV. The third and last reason I shall give for my rejecting that doctrine is, that though we should grant the real existence of those *optic angles*, &c., and that it was possible for the mind to perceive them; yet these principles would not be found sufficient to explain the phenomena of *distance*. As shall be shown hereafter.

XVI. Now, it being already shown that distance is suggested to the mind by the mediation of some other *idea* which is itself perceived in the act of seeing. It remains that we inquire what *ideas* or *sensations* there be that attend *vision*, unto which we may suppose the *ideas* of distance are connected, and by which they are introduced into the mind. And first, it is certain by experience, that when we look at a near *object* with both eyes, according as it approaches or recedes from us, we alter the disposition of our eyes, by lessening or widening the interval between the *pupils*. This disposition or turn of the eyes is attended with a sensation, which seems to me, to be that which in this case brings the *idea* of greater or lesser distance into the mind.

XVII. Not that there is any natural or necessary connexion between the sensation we perceive by the turn of the eyes, and greater or lesser distance. But because the mind has by constant *experience* found the different sensations corresponding to the different dispositions of the eyes, to be attended each with a different degree of distance in the *object:* there has grown an habitual or

customary connexion, between those two sorts of *ideas*. So that the mind no sooner perceives the sensation arising from the different turn it gives the eyes, in order to bring the *pupils* nearer or further asunder, but it withal perceives the different *idea* of distance which was wont to be connected with that sensation. Just as upon hearing a certain sound, the *idea* is immediately suggested to the understanding, which custom had united with it.

XVIII. Nor do I see, how I can easily be mistaken in this matter. I know evidently that distance is not perceived of itself. That by consequence, it must be perceived by means of some other *idea* which is immediately perceived, and varies with the different degrees of distance. I know also that the sensation arising from the turn of the eyes is of itself immediately perceived, and various degrees thereof are connected with different distances: which never fail to accompany them into my mind, when I view an *object* distinctly with both eyes, whose distance is so small, that in respect of it the interval between the eyes has any considerable magnitude.

XIX. I know it is a received opinion, that by altering the disposition of the eyes, the mind perceives whether the angle of the *optic axes* is made greater or lesser. And that accordingly by a kind of *natural geometry*, it judges the point of their intersection to be nearer, or further off. But that this is not true, I am convinced by my own experience. Since I am not conscious that I make any such use of the perception I have by the turn of my eyes. And for me to make those judgments, and draw those conclusions from it, without knowing that I do so, seems altogether incomprehensible.

XX. From all which it plainly follows, that the judgment we make of the distance of an *object*, viewed with both eyes, is entirely the *result of experience*. If we had not constantly found certain sensations arising from the various disposition of the eyes, attended with certain degrees of distance, we should never make those sudden judgments from them, concerning the distance of *objects;*

no more than we would pretend to judge of a man's thoughts, by his pronouncing words we had never heard before.

XXI. Secondly, an *object* placed at a certain distance from the eye, to which the breadth of the *pupil* bears a considerable proportion, being made to approach, is seen more confusedly. And the nearer it is brought, the more confused appearance it makes. And this being found constantly to be so, there arises in the mind an *habitual* connexion between the several degrees of confusion and distance. The greater confusion still implying the lesser distance, and the lesser confusion, the greater distance of the *object*.

XXII. This confused appearance of the *object*, doth therefore seem to me to be the *medium*, whereby the mind judges of distance in those cases, wherein the most approved writers of optics will have it judge, by the different divergency with which the rays flowing from the radiating point fall on the *pupil*. No man, I believe, will pretend to see or feel those imaginary angles, that the rays are supposed to form according to their various inclinations on his eye. But he cannot choose seeing whether the *object* appear more or less confused. It is therefore a manifest consequence from what has been demonstrated, that instead of the greater or less divergency of the rays, the mind makes use of the greater or less confusedness of the appearance, thereby to determine the apparent place of an *object*.

XXIII. Nor doth it avail to say, there is not any necessary connexion between confused *vision*, and distance, great or small. For I ask any man, what necessary connexion he sees between the redness of a blush and shame? and yet no sooner shall he behold that colour to arise in the face of another, but it brings into his mind the *idea* of that passion which has been observed to accompany it.

XXIV. What seems to have misled the writers of optics in this matter is, that they imagine men judge of distance, as they do of a conclusion in mathematics: betwixt which and the premises, it is indeed absolutely

requisite there be an apparent, necessary connexion. But it is far otherwise, in the sudden judgments men make of distance. We are not to think that brutes and children, or even grown reasonable men, whenever they perceive an *object* to approach, or depart from them, do it by virtue of *geometry* and *demonstration*.

XXV. That one *idea* may suggest another to the mind, it will suffice that they have been observed to go together: without any demonstration of the necessity of their coexistence, or without so much as knowing what it is that makes them so to coexist. Of this there are innumerable instances, of which no one can be ignorant.

XXVI. Thus greater confusion having been constantly attended with nearer distance, no sooner is the former *idea* perceived, but it suggests the latter to our thoughts. And if it had been the ordinary course of nature, that the further off an *object* were placed, the more confused it should appear; it is certain, the very same perception that now makes us think an *object* approaches, would then have made us imagine it went further off. That perception, abstracting from *custom* and *experience*, being equally fitted to produce the *idea* of great distance, or small distance, or no distance at all.

XXVII. Thirdly, an *object* being placed at the distance above specified, and brought nearer to the eye, we may nevertheless prevent, at least for some time, the appearance's growing more confused, by straining the eye. In which case, that sensation supplies the place of confused *vision*, in aiding the mind to judge of the distance of the *object*. It being esteemed so much the nearer, by how much the effort, or straining of the eye in order to distinct *vision*, is greater.

XXVIII. I have here set down those sensations or *ideas* that seem to me to be the constant and general occasions of introducing into the mind the different *ideas* of near distance. It is true in most cases, that divers other circumstances contribute to frame our *idea* of distance, viz., the particular number, size, kind, &c., of the things seen. Concerning which, as well as all other the forementioned occasions which suggest distance, I