The influence of greek authors on Francisco de Melo's theory of vision

by **Daniel Pinto***

In the history of science, of any branch of science, there are no periods of complete stagnation. One can always find at least a few small advances or a couple of false steps that turn out to be crucial. In any case, even taking into account the growing number of studies on perspective in painting, which revived interest in various topics of geometric optics, it would not be out of place to classify the 14th and 15th centuries as two reasonably quiet centuries in the history of optics. So when we look at the theory of vision presented by the Portuguese mathematician Francisco de Melo (born about 1490), it is unsurprising that his approach is still deeply linked to the dominant theories in the Middle Ages. The influence of Ibn-al Haytham, also known by the Latinized name of Alhacen, who wrote, in the 11th century, one of the most groundbreaking treatises on optics, and the impact of Witelo, a 13th-century author, on Melo's thinking would be easily detectable even if he had not referred to them. Still, the truth is that Melo mentions the names of both in the *Corollary to Euclid's Perspective*, a text dedicated to the nature and fundamental principles of vision (and written to complement Melo's version of Euclid's *Optics*). But besides his interest in the medieval period, Francisco de Melo, who for some years attended the University of Paris, back then one of the most important academic centres in the world, was nonetheless a man of his time, strongly influenced by the Renaissance movement that sought to revisit ancient Greek texts. Here we will try to display a significant number of concepts that Melo retrieved from Greek authors to build his theory of vision.

The intersection of ideas, the succinct way in which Melo condenses and cross-references, in a few pages, many of the main currents in optics known until then, is one of the most peculiar facets of the *Corollary to Euclid's Perspective*. That whole process of synthesis is backed up by Melo's tendency towards abstract thinking. He also makes use of experimental results and some concrete examples, but it is in the manipulation of mathematical tools that he shows greater ability. To write his version of Euclid's *Optics*, Melo completely reworked the very unclear demonstrations that were available in the Latin edition (translated from Greek) by Bartolomeo Zamberti, printed a few years earlier (1505). He did not just make small adjustments; almost all the demonstrations were rebuilt from scratch with remarkable detail and precision. Even though, to complete that task, Melo may have followed some of the comments of Pierre Brissot, with whom he worked in France, such an ambitious programme would have proved impossible had Melo not been a talented mathematician himself. In the *Corollary to Euclid's Perspective*, maybe because of the hybrid nature of the text (a combination of geometry, anatomy and natural philosophy), he is not so original or audacious in his demonstrations, but it is still possible to find substantial differences when we compare them with proofs of similar results in previous works on the subject.

Euclid

In the last paragraph of the *Corollary to Euclid's Perspective*, Melo warns the reader that the theory of vision he had elaborated had been quickly put together and that it may not be perfectly articulated. This self-inflicted depreciation of his own text is intended not only to point out that Melo did not invest much time in dealing with

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Figure 1.—Johann Zahn, *Oculus Artificialis Teledioptricus Sive Telescopium*, 1685

the details of a complex field, that he wants to summarise in an original way, but also to draw attention to the fact that his version of Euclid's *Optics* is a much more ambitious project. Although the *Corollary to Euclid's Perspective* could be read as a completely autonomous text, it would be disconcerting if the main ideas defended by Euclid in the *Optics* had not been incorporated into Melo's theory of vision. But that is not the case. Euclid (4th–3rd century BC) is possibly the strongest presence in Melo's theory of vision. This is evident in the structure of the text, which is very Euclidean, with two postulates followed by propositions and lemmas, as well as in the more substantive content.

Euclid is considered an extramissionist since, in one of the definitions of the *Optics*, he admits the existence of rays travelling from the eye to the objects, despite not using this orientation in his proofs (Figure 1). For centuries, even after Kepler, the extramission (or emission) hypothesis had many supporters who rejected the intromission theory, in which rays emitted by the eye were not necessary to explain vision, only rays travelling in the opposite direction (a position advocated, for example, by Alhacen). Melo agreed that something had to reach the eyes, but his theory of vision does not dispense with the emission of visual rays. Furthermore, Melo is also aligned with Euclid in terms of both the rectilinear and

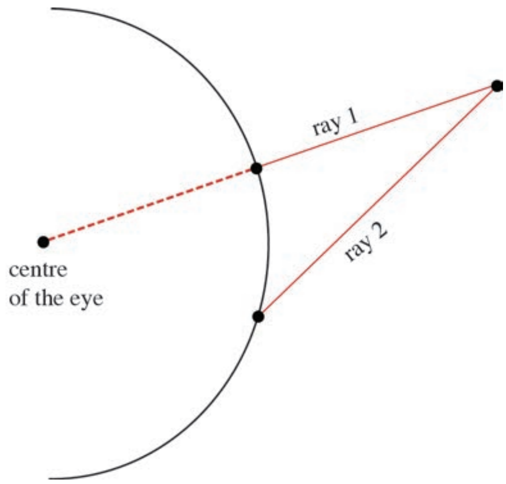

Figure 2.—Ray 1 (the perpendicular ray) is shorter than ray 2.

the discrete nature of those rays. For Melo, visual rays are not continuous, there are intervals between them, which would explain why, in an instant, we might not see a small needle on the ground (fallen between two consecutive rays) but, by moving our eyes a little, the needle might appear to us (after being hit by some visual ray). In Euclid's *Optics*, the eye is represented by a point, and binocular vision is not considered (with a few exceptions). Melo does not devote much time to this subject either. He only directly deals with binocular vision in three of the twenty propositions.

Even when he addresses anatomical issues, which are absent from the Euclidean text, Melo transfers the analysis of the components of the eye to a geometric setting. It is undoubtedly Euclid's *Optics*, the earliest extant treatise on geometric optics, that Melo has as his primary reference. And if the style of Euclid's *Optics* is present in the geometrisation of the anatomical features, the *Elements* are called upon in the course of various demonstrations—particularly the results from Book III—involving circles and circumferences.

Aristotle

Although Aristotle is explicitly mentioned several times, his most relevant contribution to Melo's work is tacitly included in the first postulate of the *Corollary to Euclid's Perspective*, formulated with an undeniable Aristotelian slant:

> Firstly, it must be accepted that every natural agent acts more quickly and vigorously towards what is near than towards what is far.

It is this postulate that will allow Melo, later on, to establish that faithful and distinct vision is realised by means of rays that fall perpendicularly on the eye, the ones with the shortest length (Figure 2). If all the rays, and not just the perpendicular ones, were of equal importance, the image in the eye would appear confused, which does not occur in a person without ocular disorders.

There are passages in Aristotle´s body of work where he seems to be moving closer to the extramission theory, namely in his studies of the rainbow. But, unlike Euclid, he is generally connected, by commentators, with the intromission theory. Melo is not an exception and also associates Aristotle with the idea that something from a visible object must reach the eye. However, in the *Corollary to Euclid's Perspective*, Francisco de Melo often mentions Aristotle in paragraphs in which he wants to reaffirm that his theory of vision does not dispense with rays emitted by the eye. For instance, Melo uses an observation that he partly attributes to Aristotle (why do we see further and more clearly through a tube or with half-closed eyes?) to reinforce his appetite for extramission theories. According to Melo, this is due to the greater number of rays that hit the object since, under normal conditions, some of them would disperse. Curiously, the oddest reference to Aristotle is also related to extramission. For Melo, something must be travelling from the eyes to the objects since, following an observation from Aristotle's *On Dreams*, menstruating women allegedly infect mirrors.

Despite the fact that Melo does not always stress the relevance of colour in his theory of vision, he seems to agree with Aristotle for whom colour was not only a characteristic of objects (not dependent on the observer or other factors) but precisely what makes them potentially visible. As for the importance of the eye, Melo is again in tune with Aristotle, considering vision to be dominant over the other senses.

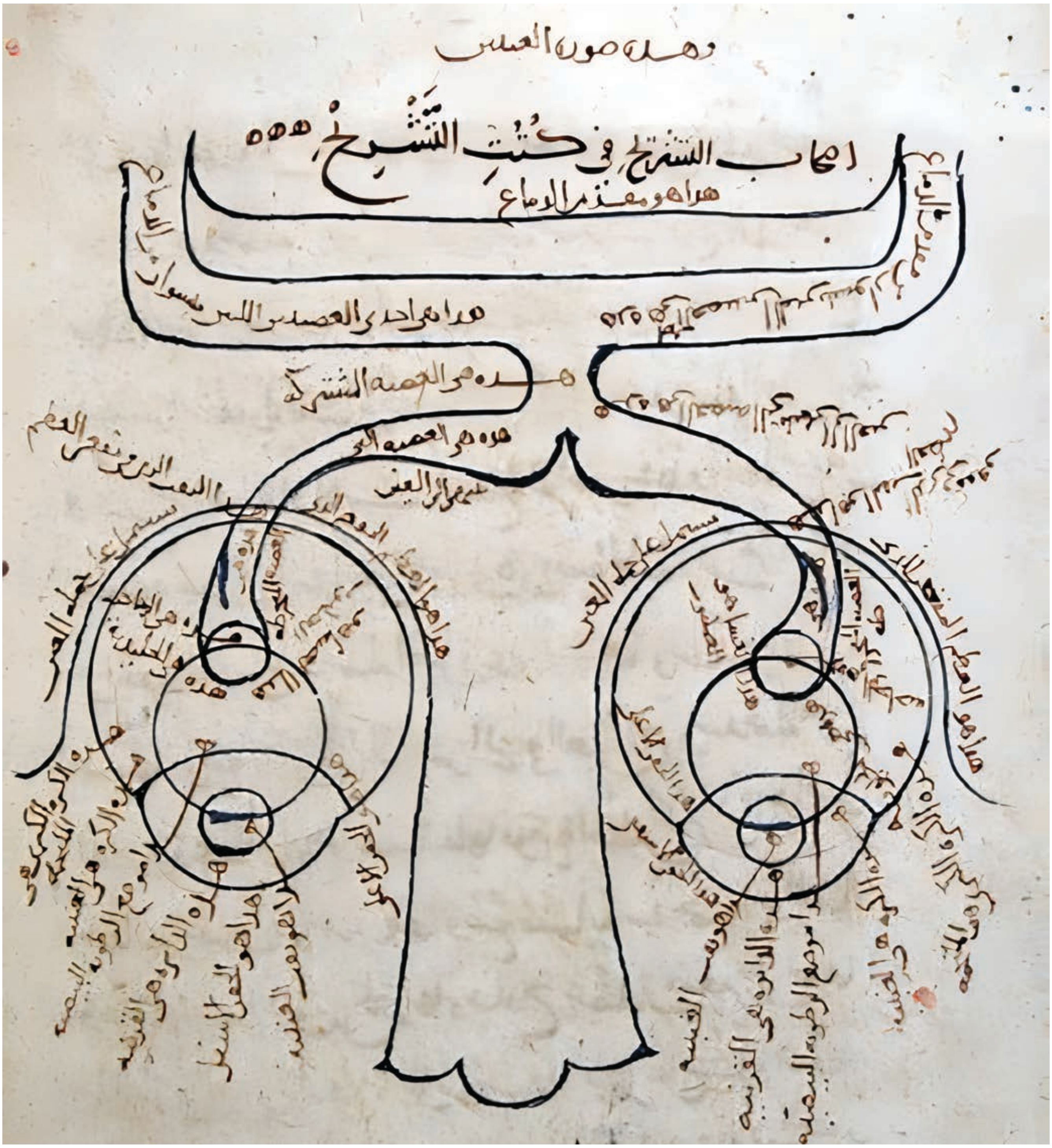

Figure 3.—The eye according to Alhacen (Ibn al-Haytham). MS Fatih 3212, vol. 1, fol. 81b, Süleimaniye Mosque Library, Istanbul.

Plato

With Plato, as with Euclid, Francisco de Melo shares the belief in the extramission hypothesis. An affinity that Melo emphasises in his text after remarking that the eyes of many living beings glow in the dark. Melo is, in some sense, very close to the idea of *visual fire* that we can find in the Platonists. But Plato's most significant influence on Melo's theory of vision is related to the role of light. Contrary to Alhacen's approach, light is not at the centre of Melo's theory, but it is essential for vision to occur. For Plato, vision is only possible if the visual fire combines with light, an insight that Melo, with some adaptations, also embraces. In the view of Aristotle, light is a state that requires the presence of some luminous body so that a *potentially transparent homogeneous medium* (that can be found especially in air and water) could become *actually transparent*. As opposed to Plato, for Aristotle this actualisation is a qualitative change, there is no movement involved. On this topic, Melo seems to be closer to Plato, although his position is somewhat ambiguous.

Galen

Francisco de Melo's interests were not only focused on the nature of visual rays, the importance of light, or the more abstract concepts in the background. The anatomical details of the eye were also the object of his attention. For Melo, the eye is made up of three tunics (Cornea, Uvea and Arachnoid) and three humours (Albugineous Humour, Vitreous Humour and Crystalline). Melo justifies the absence of the Conjunctiva, which Galen (2nd century AD) includes in his description of the eye, because it is an external part that does not interfere in the process that leads to vision, despite its important function of connecting the eye to the bone in the head. In the manuscripts of the *Corollary to Euclid's Perspective* that have survived, the figure representing the eye is missing. However, one can understand, by Melo's description, that the anatomy of the eye that he proposes is not only inspired by Galen's but also includes other later contributions, in particular the one that Alhacen popularised in his most famous book, *De aspectibus/Kitāb al-manāzir* (Figure 3).

Contrary to what happens with the Conjunctiva, about which they have at least a formal discrepancy, Melo and Galen agree that the seat of vision is located in or around the Crystalline (the *lens* of the eye), an idea that Aristotle also defended.

Theodosius of Bithynia

Since Melo's approach is very geometric, many of the propositions involving the eye are actually results about spheres. To justify the relative position of the components of the eye, or the shape of the common sections of the humours that make it up, Melo resorts to geometry. Sometimes through results that he himself demonstrates, in other occasions using propositions from Theodosius' *Sphaerics*. An example of the first case is the Lemma in which Melo proves the following:

> If two unequal circles intersect, each will be divided into unequal arcs, and the smaller arc of the larger circle will be contained within the smaller circle. In the same way, two unequal spheres will not be cut into equal parts, and the smaller section of the larger one will be contained within the smaller one.

Melo's demonstration makes use of some results from Euclid's *Elements* and also of Proposition Fifteen, which he has proved earlier. The referred proposition can serve us as an example for the second case, since in order to show that a particular line passes through the centre of certain spheres (that are abstract representations of some components of the eye), Melo uses results from Theodosius (2nd century BC) to shortcut the argument. According to some authors, including Thomas Heath, Theodosius was not a particularly original mathematician. Heath goes so far as to describe him as nothing but a *laborious compiler*. Nevertheless, the theorems and proofs from Theodosius' textbook appear in important works on geometric optics, not only in that of Francisco de Melo. Despite Witelo never mentioning Theodosius in his treatise on optics (Witelo's *Perspectiva*), the similarity of various results and proofs to those we can find in *Sphaerics* indicates that he had a thorough knowledge of Theodosius' work.

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