The Institute of Ismaili Studies

Optics

Medieval Islamic Civilization, An Encyclopaedia

Nader El-Bizri

Optics, as a scientific discipline that explores the nature and comportment of vision and light, finds its earliest methodic roots in Euclid's elementary treatise, the *Optika* (ca.300 BCE), which eventually was geometrically systematised by Ptolemy (d. ca. 165 CE). According to those polymaths, vision results from the emission of actual light rays from the eye, which take the shape of a cone whose vertex is at the centre of the eye and its base on the surfaces of visible objects. This optical theory reconfirmed Plato's account in the *Timaeus*, wherein it was stated that vision is attributed to the soul's non-consuming fire, which provides the eye with a light that gets emitted into the surrounding air to meet lit objects. This picture was also affirmed in Galen's (d. ca. 200 CE) anatomy of the eye, whereby he argued that vision occurs due to the eye's spirit, which passes through the luminous channels of the optical nerve and is radiated onto the external environment as a light ray that travels at an infinite velocity. A similar observation regarding the speed of light was also made by Heron of Alexandria (d. 75 CE) in his work *Catoptrics*. These mathematical "emission" theories of vision contrasted the physical "intromission" accounts of sight like what is encountered in Aristotle's *De anima* (*Tract on the Soul*) wherein it was ambivalently stated that visual perception results from the introduction of the form of the visible object without its matter into the eye. Although the channels of the transmission of Euclid's Greek *Optika* were indeterminate, its Arabic version was preserved under the title *Kitab Uqlidus fi ikhtilaf al-manazir*. As for Ptolemy's text, it is known from its Greek source, whereas its Arabic rendition is only recoverable from fragments of Latin translations. One of the earliest engagements with optics in Islam may be traced back to Hunayn ibn Ishaq's (d. ca. 873 CE) Galenic studies and al-Kindi's (d. ca. 870 CE) commentaries on Euclid's *Optika*; the latter surviving in Latin under the title *De aspectibus* and were directed by philosophical speculations more than geometric demonstrations.

The most remarkable accomplishment in the science of optics is ultimately achieved in Ibn al-Haytham's (Alhazen; d. ca.1039 CE) monumental *Kitab al-manazir* (*The Optics*: ca.1027 CE), which was translated into Latin as *De aspectibus* (ca. 1270 CE) and had a focal impact on the tin folding of the perspective tradition in the history of medieval science and Renaissance art. He lived and worked under the patronage of the Fatimid Dynasty, based in Cairo. Gathering the findings of the Ancients, Ibn al-Haytham was able to overcome the main dispute over the nature of vision between the Greek mathematicians and physicists. Rejecting the claim that vision occurs by way of the emission of a light ray from the eye, Ibn al-Haytham systematised the intromission account of vision by demonstrating that seeing results from the introduction of the rays of light into the eye in the shape of a virtual conical model. He moreover supplemented his *Optics* with a *Treatise on Light* (*Risala fi l-Daw'*) that studied the radiating dispersion of light across transparent media in a rectilinear propagation. His optical writings did also incorporate catoptrical explorations of reflection on planar, spherical, cylindrical, parabolic, and conical mirrors. He also integrated the study of lenses and magnification within the science of optics and verified his theoretical hypotheses with controlled tests and experimental installations. The refraction of light also constituted a central subject in his *Optics* that assisted him in his explorations in astronomy and meteorology.

Although his optical tradition was comprehensively studied and integrated within the European Latin scientific impetus, it, unfortunately, confronted a period of long interruption in transmission within the medieval Islamic civilisation. A parallel engagement in ocular investigations is Ibn Sina's (the noted philosopher and physicians) (Avicenna. d. 1037 CE) critical espousal of the Aristotelian theory of vision which classified optics as a branch of physics rather than mathematics. However, in diverging from Aristotle's *Meteorology*, Ibn Sina ultimately advanced an alternate explanation of the phenomenon of the rainbow.

Following his tradition, Nasir al-Din Tusi, the Shia scholar and astronomer, (d.1274 CE) wrote a commentary on Euclid's *Optika* that did not show signs of being aware of the optical writings of Ibn al-Haytham. However, the most notable progress in optics which built on Ibn al-Haytham's results and disseminated them is creditably attributed to *Tanqih al-manazir* (*The Revision of the Optics*) by Kamal al-Din al-Farisi (d.1320 CE). Informed by Ibn Sina's writings, Kamal al-Din revised Ibn al-Haytham's elucidation of the nature of the rainbow and the halo. Using geometrical constructs to demonstrate how the rainbow results from refraction of light falling on individual raindrops, Kamal al-Din further substantiated his hypothesis by experimentally modelling this process on the passage of light through a spherical vessel filled with water. Following this latest advancement in classical optics, the study of vision in the Muslim world did not progress beyond synoptic summarizations of earlier sources.

Primary Sources

Euclid. *The Arabic Version of Euclid's Optics: Kitab Uqlidus fi Ikhtilaf al-Manazir*. Edited and translated by Elaheh Kheirandish. Berlin: Springer Verlag, 1999.

Ibn al-Haytham. *Kitab al-manazir*. Edited by Abdelhamid I. Sabra. Kuwait: National Council for Culture. Arts and Letters, 1983.

— — *The Optics of Ibn al-Haytham, Books I-III, On Direct Vision*. Translated by Abdelhamid I. Sabra. London: The Warburg Institute, University of London, 1989.

Ibn Sina. *Kitab al-shifa', Kitab al-nafs*. Edited by Fazlur Rahman. Oxford: Oxford University Press, 1960.

Further Reading

Beshara, Saleh O. *Ibn al-Haytham's Optics*: *A Study of the Origins of Experimental Science*. Minneapolis: Bibliotheca Islamica, 1977.

Gul, Russell. "The Emergence of Physiological Optics." In *Encyclopaedia of the History of Arabic Science*. Vol. II. Edited by Roshdi Rashed and Regis Morélon. London and New York: Routledge, 1996.

Lindberg, David C. *Theories of Vision from al-Kindi to Kepler*. Chicago: University of Chicago Press, 1976.

— — "The Western Reception of Arabic Optics." In *Encyclopaedia of the History of Arabic Science*. Vol. II. Edited by Roshdi Rashed and Regis Morélon. London and New York: Routledge, 1996.

…Please see copyright restrictions on page 1

Rashed, Roshdi. “Geometrical Optics.” In *Encyclopaedia of the History of Arabic Science*. Vol. II. Edited by Roshdi Rashed and Regis Morélon. London and New York: Routledge, 1996.

— — *Optique et mathématiques, recherches sur la pensée scientifique en arabe*. Aldershot: Variorum Reprints, 1992.

Sabra, Abdelhamid I. “The Physical and the Mathematical in Ibn al-Haytham’s Theory of Light and Vision.” In *The Commemoration Volume of Biruni International Congress in Tehran*. Vol. 38. Tehran: High Council of Culture and Arts, 1976.

— — “Sensation and Inference in Alhazen’s Theory of Visual Perception.” In *Studies in Perception: Interrelations in the History of Philosophy and Science*, Edited by Peter K. Machamer and Robert G. Turnbull. Ohio: Ohio State University Press, 1978.

— — “Optics, Islamic.” In *Dictionary of the Middle Ages*. Vol. 9. Edited by Joseph R. Strayer. New York: Charles Scribner’s Sons, 1987.

…Please see copyright restrictions on page 1