

Al-Haytham the Man of Experience. First Steps in the Science of Vision

Rosanna GORINI*

* Institute of Neurosciences-Laboratory of Psychobiology and Psychopharmacology, Rome, Italy.
e-mail: R.Gorini@ipsifar.rm.cnr.it

Summary

Abu 'Ali al-Hasan ibn al-Hasan ibn al-Haytham (965-1039 A.D) was one of the most significant figures in the history of optics between antiquity and the 17th century. His explanation of the vision has been revolutionary in the history of medicine and vision. In his *Kitab al-Manazir* he studied optical illusions, the structure of the eye, perspective, atmospheric refractions etc. In particular his theory in which the principles of light and perspective are explained for the first time in the Middle Ages, had a great impact upon European culture of the medieval and modern eras.

Key Words; Al-Haytham, Kitab al-Manazir, Optics, Vision.

Abu 'Ali al-Hasan ibn al-Hasan ibn al-Haytham (965-1039 A.D), sometimes called al-Basri (from the city of Basra, his birthplace) or al-Misri (since he came from Egypt) is more often known in Europe as Alhazen or Alhacen (the latinization of al-Hasan) and Avenatan or Avennathan. He was identified towards the end of the 19th century with the Alhazen, Avennathan and Avenetan of medieval Latin texts (1). Little is known about al-Haytham's life. Most probably he was born in Basrah in Iraq, and was educated in Basrah and Baghdad. His father was a civil servant, so al-Haytham was sufficiently well educated. We know that he travelled a lot, especially in Spain, and that he spent a long period of his life in Cairo during the rule of the Fatimid caliph al-Hakim bi-Amr Allah (985-1021 A.D.). The munificence of al-Hakim to scholars and scientists, according to Sami Hamarneh had attracted al-Haytham into going to Fatimid Egypt (2).

According to Haidar Bammate, al-Haytham was the first to support the building of a dam near Aswan to raise the water level of the Nile (3). He submitted to al-Hakim a hydraulic plan for regulating the inundations of the Nile. We do not know if that project was refused by the caliph or if al-Haytham was not able to carry on it, perhaps for its expensiveness. In a 13th century report it is said that al-Haytham, after realizing that it was not possible to make his project

concrete, pretended to be mad to avoid al-Hakim's anger and punishment. As a consequence he was confined in a house where he lived for many years, until the death of the caliph, twelve years later. After these events al-Haytham continued to live in Cairo near the al-Azhar University, until his death.

He was a very erudite man, like many medieval men. He expounded, among the others, the theories of Aristotle, Galen and Ptolemy and was devoted on philosophy, physics, medicine, optics, astronomy and mathematics. He wrote about one hundred books on these and other subjects. However his most important studies were related to the optic matter and his influence on the western thoughts is mainly due to his works in the field of optics, in which the basis lays of the optical knowledge in later Christian and Islamic Middle Age. Hence, Al-Haytham is considered one of the most significant figures in the history of optics between antiquity and the 17th century. His explanation of the vision has been revolutionary in the history both of medicine and optics and has modified the idea that ancients had about light and their theories on the anatomy and the physiology of the eye (4).

The light has been the subject of various studies since antiquity and the nature of the physical relation between eyes and objects has been a considerable problem to the early 17th century. The Greek philoso-

phers and scholars speculated about this connection advancing some conflicting theories. The earliest form of the theory of vision, called “atomistic intromission theory” is due to Leucippus of Miletus (about 490/80-420 B.C.) and Democritus of Abdera (about 460-370 B.C.). They hypothesized that atoms streaming in various directions from an object produce visual sensations by entering the eyes of observers. An alternative theory, called “extramission theory”, is due to other pre-Socratic philosophers such as Empedocle of Acragas (about 495/90-435/30 B.C.). They supposed that the eyes send out rays of light to view the objects. Plato (about 427-347 B.C.) tried to unify both the intromission and extramission theories and his pupil Aristotle (384-322 B.C.) advanced a “mediumistic theory” by which the eye receives rays rather than direct them outward. In particular, according to Aristotle, in the process of human vision the object being looked at somehow altered the medium between the object itself and viewer’s eye. Thus it was possible to see the object because the medium’s alteration propagated to the eye. The extramission theory was reviewed and extended by Euclid of Alexandria (about 325-265 B.C.), Claudius Ptolemy (about 85 B.C.-165 A.D.) and Galen (about 129 B.C.-210 A.D.) Al-Haytham clashed with the extramission theory and affirmed that the rays emanate in straight lines towards the eyes from every point of a visible object. Starting from the observation that, when the eyes are injured by a strong light, the observer has a sensation of pain, followed by a persistence of the images he deduced that light must be an external agent which enters the eye and temporarily modifies its structure. Moreover, basing himself on Aristotle’s studies, he considered that the eye perceives only the light and the colours and that the estimate on the size, the distance and the shape of the observed objects derives from more complex rational judgements.

The knowledge of the role played by the brain in interpreting what is seen by the eyes allowed Al-Haytham to explain optical illusions, including the “Moon illusion”. This phenomenon through which heavenly bodies look bigger at the horizon than at the zenith, has been recorded and investigated since antiquity and it has been referred to as the “moon

illusion” since it is particularly clear in the case of the moon. Al-Haytham explained why the moon and the sun appear larger on the horizon. He realized that our brain is deceived by objects like trees, hills or houses on the horizon, into thinking that the moon is getting bigger. When the moon is high in the sky, there are no references on the ground with whom we can compare it and thus it looks smaller. According to Ross & Ross al-Haytham was probably the first author to explain the moon illusion by the size-distance invariance principle (5).

His main book is a seven volume work, *Kitab al-Manazir*, which he completed between 1028 and 1038. Initially al-Haytham’s work was available in Arabic language and was therefore accessible only to very few European scholars until the 13th century when, in 1270 *Kitab al-Manazir* was translated into Latin by the Polish scholar Witelio. It was widely available in Europe when it was first published by Frederick Risner at Basel in 1572 as *Opticae Thesaurus, Alhazeni Arabis libri septem*. In the Risner’s edition the Gerard of Cremona’s Latin translation *De crepusculis et nubium ascensionibus* and the *Optica* of Witelio are also incorporated (6). The *Kitab al-Manazir* - exemplary for combining natural philosophy and mathematics - inspired many books on optics from the thirteenth to the seventeenth century and exerted a great influence upon western scholars, as for example Roger Bacon (1214-1292/4 A.D.), Witelio (1230/35-1275 A.D.) and Johannes Kepler (1571-1630 A.D.). According to Howard, the *Kitab* formed the basis upon which Keplero solved the problem of image formation (7) and, according to the translation by Lindberg, Keplero says: “I say that vision occurs when the image of the whole hemisphere of the world that is before the eye is fixed on the reddish white concave surface of the retina. How the image or picture is composed by visual spirits that reside in the retina and the optic nerve, and whether it is made to appear before the soul or the tribunal of the visual faculty by a spirit within the hollows of the brain or whether the visual faculty like a magistrate sent by the soul goes forth from the administrative chamber of the brain into the optic nerve and the retina to meet the image, as though descending to a lower court - this I leave to be disputed by the physicists” (8).

In the East, two distinguished Persian scholars, Qutb al-Din al-Shirazi (1236-1311 A.D.) and Kamal al-din al-Farisi (1260-1320 A.D.), the commentator of the *Kitab*, followed up and extended al-Haytham's studies, helping in the popularization of al-Haytham theories in the Islamic world.

They also advanced theories on the rainbow superior to that of al-Haytham (6). Ibn al-Haytham initial theory concerning rainbow was that it origins by the reflection of light from the sun through clouds, before reaching the eye. They proposed a model where a ray of sun light is refracted twice by a water droplet with one or more reflections occurring between the two refractions (9). In medieval Islam in the 13th and 14th centuries there was an interest so great in rainbow, ('ilm qaus quzah) that a special science on it was built up (6).

In his *Kitab*, al-Haytham investigated, among other arguments, optical illusions, the structure of the eye, binocular vision, perspective, atmospheric refraction, comets, shadows, eclipses, rainbow, mirages and the camera obscura. According to Winter al-Haytham was not the first to mention the camera obscura, whose action had been understood in an elementary way by the Chinese before 300 B.C. but he was the first to give of it a mathematical explanation (6). He expounded for the first time the use of camera obscura in the observation of solar eclipses (1).

According to the majority of the historians al-Haytham was the pioneer of the modern scientific method. With his book he changed the meaning of the term optics and established experiments as the norm of proof in the field. His investigations are based not on abstract theories, but on experimental evidences and his experiments were systematic and repeatable. As Rosmorduc affirms: Al-Haytham insists on the importance of "investigating by induction existing phenomena and in this way distinguishing the properties of individual things. From here, we may turn to research and comparison, in a gradual and orderly way, criticizing premises and being careful about results" (10).

In conclusion al-Haytham was an outstanding figure of scientist and his researches are characterized by a great experimental skill: he used particular precautions to do his work and he carried out every experiment with the best devices he could make. In particular in his *Kitab* al-Haytham new approach to the studies of optics in the Middle Ages is present starting from the basic physiological principle according to which sight (al-basar) consists of various layers, coats and bodies and its principle and origin are situated in the frontal part of the brain. His theory in which an important analysis of the physical process of sight can be found explains for the first time in the Middle Ages the two principles of light and perspective whose impact upon European culture of the medieval and modern eras has been very relevant.

As a proof of the relevance of his studies, there is on the moon, near the east margin of the Mare Crisium, a crater called Alhazen (15.9° N/ - 71.8°E; diameter 33 km.).

REFERENCES

1. The Encyclopedia of ISLAM - New Edition - Leiden, E.J. Brill and London Luzac & Co, Eds., 1960.
2. Hamarneh S: Medicine and pharmacy under the Fatimids. Hamdard Med. 1979 Dec.; 22(7-12): 33-69.
3. Bammate H: Apport des musulmans à la civilisation. Tawhid/Centre Islamique de Genève. 1998: 110.
4. Muslim & Arab Perspectives. International Islamic Magazine. 1995; 2(11-12):81-9.
5. Ross HE, Ross GM: Did Ptolemy understand the moon illusion? Perception 1976; 5(4):377-85.
6. Winter H.J: The Optical Researches of Ibn Al-Haitham. Centaurus. 1954; 3: 190-210.
7. Howard IP: Alhazen's neglected discoveries of visual phenomena. Perception 1996; 25(10): 1203-17.
8. Lindberg DC: Al-Hazen's Theory of vision and its receptor in the West Isis 1967; 58: 321-41.
9. Burns K: The Muslim Contribution to Optics. <http://198.65.147.194/english/Science/2001/02/article16.shtml>.
10. Djebbar A: Grecker than the Greeks. Une Histoire de la science arabe, entretiens avec Jean Rosmorduc (A History of Arab Science-Conversations with Jean Rosmorduc). Seuil: Paris, 2001: 384.