Ibn al-Haytham 11th century test of Visual Illusions

Dr. Omar Khaleefa*

Abstract

The present study showed that Ibn Al-Haytham employed throughout *Maqala* III of *Kitab al-Manazir* or "The Book of optics" the term *aghlat al-basar* “error of visions” or visual illusions in modern psychological terms. Additionally, he described a series of *I'tibar* or experiments for measuring them. His test was applied to a group of *mu'tabroun* 1077 “8-70 years” from Bahrain. The number of males 498 “46,2%” and females 579 “53,8%”. The group was selected with respect to seven age groups as well as five educational levels. The most remarkable finding of the present study is that Ibn al-Haytham's 11th century replicates to 78.2% by the measures under modern conditions. The study also showed that Ibn al-Haytham's five experiments were reliable and valid.

*Associate Professor,University of Khartoum, Sudan .

Introduction

Kitab Al-Manazir

Ibn Al-Haytham, an early Arab optician. In the first half of the 11th century, produced a manuscript titled "*Kitab Al-Manazir"* or The Book of Optic. Sabra, the historian of optics at Harvard University, relied on the *al-Fatih's* manuscript of *Kitab al-Manazir* for his excellent edition, with introduction, Arabic-Latin glossaries and concordance tables. The National Council for Culture, Arts, and Letters in the State of Kuwait published the first volume of *Kitab al-Manazir*, which has the Arabic text of Books 1-111 "Sabra, 1983". The book has also been translated by Sabra and published with introduction, commentary, glossaries, concordance and indices by Warburg Institute at the University of London "Sabra, 1989".

It is divided into seven *Maqalas* or Books. *Maqala* 1 discussed vision generally, *Maqala* 11 detailed the visual properties, *Maqala* 111 described errors of sight in what is perceived directly, and their causes. *Maqala* 1V described the manner of visual perception by refraction from smooth bodies, *Maqala* V described the positions of images, *Maqala* V1 described visual errors in what is perceived by reflection, and their causes, *Maqala* V11 explained visual perception by refraction through transparent bodies whose transparency differs from that of air.

al-ghalat al-basari or error of vision

Ibn al-Haytham employed throughout *Maqala* 3 or Book 111 of *Kitab al-Manazir* the term *aghlat al-basar* or error of vision such as *al-ghalat fi al-bo'd* or distance, *al-ghalat fi al-wad'* or position, *al-ghalat fi al-tagsim* or solidity, *al-ghalat fi al-shakl* or shape, *al-ghalat fi al-o'zm* or size, *al-ghalat fi al-tafaruq* or separation, *al-ghalat fi al-ittisal* or continuity, *al-ghalat fi al-a'dad* or number, *al-ghalat fi al-al-harakah* or motion, *al-ghalat fi al-sukun* or rest, *al-ghalt fi al-khushuna* or roughness, *al-ghalat fi al-malasa* or smoothness, *al-ghalat fi al-shafif* or transparency, *al-ghalat fi al-kathafa* or opacity, *al-ghalat fi al-dhil* or shadow, *al-ghalat fi al-dholma* or darkness,

al-ghalat fi al-husn or beauty, *al-ghalat fi al-qobh* or ugliness, *al-ghalat fi al-tashaboh* or similarity, *al-ghalat fi al-ikhtilaf* or dissimilarity.

Ibn Sina, an early Persian Muslim scholar, in *Kitab al-Shifa* has used the term *alkhata' al-basar* or mistake of vision "Qanawati & Zai'd, 1975". Modern psychology uses the term visual illusions. Two contemporary psychologists "Howard, 1996; Taha, 1990" employed Ibn al-Haytham's term *al-ghalat al-basari* as *al-khida' al-basari* for visual illuions. There are both "binocular" and "monocular" visual states and Ibn al-Haytham's contribution is concerned with the binocular vision. He noted that because the two eyes are slightly separated in the head, the two retinal images of a real scene are slightly different. Boring (1957) observed that binocular vision furnished one of the most obvious conundrums in this field. Look at something with both eyes and nearly always there is only one 'look', whether one thinks about the objects or about the eyes that are seeing it. How does two-eyed vision get single? Boring discussed three theories.

The astronomer Kepler (1611), claimed that singleness of vision is due to projection of the seeing to the object seen, the object theory, which works in touch where a pencil feels like a single pencil when held between two fingers. Porta, a physicist, had previously suggested (1593) that the two retinal images alternate in perception, first one and then the other, as occurs in what is now known as retinal rivalry. Gall, the anatomist-phrenologist, also held this view. The correct explanation, however, was anatomical. Half of the fibers from each retina cross at the optic chiasma and half do not. This fact suggests that the projections of the two retinas on the brain by the nerve fibers are superimposed, and that singleness of vision results when one brain pattern coincides point-for-point with the other. As early as the second century Galen, conceived this kind of function for the chiasma, and Newton accepted the view in 1717. In the nineteenth century Muller is found accepting it and elaborating it "Boring, 1957".

Perhaps, the most remarkable series of neglected theories and discoveries in Ibn al-Haytham's book *Kitab al-Manazir* or Optics are those concerning binocular vision, which are set in Chapter 2 of Book 111. His ideas on how the optic nerves combine in the optic chiasma were

described in Book 1 and were derived from Galen. These ideas have been well cited; however, Howard found no later reference to the ideas on binocular vision contained in Book 111 and most of these ideas were not described again until the nineteenth century “Howard & Rogers 1995”. Ibn al-Haytham mentioned that an object appears double when one eye is pushed by the finger and, like Galen, pointed out that the visual axes converge on the object of interest. He wrote: "when one eye moves for the purpose of vision, the other eye moves for the same purpose and with the same motion; and when one of them comes to rest, the other is at rest" “See Appendix 1 for Ibn al-Haytham's anatomy of the eye”.

Ibn al-Haytham concept of I'tibar or test

In the Optics of Ibn al-Haytham there appeared for the first time a distinct concept of experiment consistently associated with three cognate words, *i'tabara*, *I'tibar* and *mu'tabir*, which the Latin translation of the book rendered as *experimentare*, *experimentatio* and *experimentator*, respectively. Sabra argued that the appearance of this concept of experiment, being essentially different from the Aristotelian and medical *emeiria* “almost always expressed in the Arabic literature by *tajriba*, experience” should be regarded not as a development within Aristotelianism or Galenism but as a 'result of taking over into optics an idea [of testing] which had had an established career in astronomy' “Sabra, 1971”. The belief that Ibn al-Haytham's method is a continuation of Ptolemy's method is based on a superficial comparison. The similarity is less evident when a strict comparison of the two methods is made “Omar, 1981”.

In Arabic, common usage of the verb *'abara* “from the trilateral root 'BR” and of the eight form *i'tabara* reveals two related senses which persisted in the later technical application of the latter term. One is the general sense of examining “something”, and the other is that of comparing or measuring something with another. Thus, *'abara* could mean to examine or seek to determine, as in *'abara al-darahima*, to weigh the *dirhams*, seeking to know their value. Similarly, *i'tabara al-shay'a* is to examine or test the thing; and *i'tabara ba'da al-kitabi bi-ba'dihi* is 'to consider and compare one part of the book with another part, in order to understand it'. *I'tabara* occurs in the

Qur'an “lix.2” in the sense of to take heed or warning or example from past happenings, the sense frequently encountered in works of history or moral teaching, as, for example, in the title of Ibn Khaldun's famous book, *Kitab al-'Ibar* “Sabra, 1971”. Ibn al-Haytham's concept of *al-ghalat al-basari*, he used in connection with binocular vision and his method of *I'tibar* or test, are needed, empirically, to be verified.

Aims of the empirical study

First: How well does Ibn-Haytham's test replicate at the beginning of the 21th century?

Second: what is the mean of performance in the different experiments by Ibn al-Haytham?

Third: what is the influence of age on *aghlat al-basar* or error of vision?

Fourth: what is the influence of gender on *aghlat al-basar*?

Fifth: what is the influence of education on *aghlat al-basar*?

Sixth: what is the interaction between age and education on *aghlat al-basar*?

Seventh: what is the reliability of Ibn-Haytham test?

Eighth: what is the validity of Ibn-Hyatham test?

Method

Mo'tabaroun or Sample

In the present study we use the term *mu'tabir* for experimenter or examiner and *mu'tabireen* for experimenters or examiners and *mu'tabar* for examinee, *mu'tabaroun* for examinees, subjects or sample. For example, Ibn al-Haytham wrote : "*thomma yarfa' al-mu'tabar*"; "*thomma ya'tamid al-mu'tabar*"; "*idha nazar al-mu'tabar*"; "*thomma yanbaghi lil-mu'tabar*". In all these cases al-mutabar means the examinee or the participant.

As a pilot study, Ibn al-Haytham's I'tibar or test was applied to a group of 50 students from the University of Bahrain both males and females to ensure the suitability of instructions, Ibn al-Haytham's terms, positions of lines, pin objects, and angles. The main 1077 *mu'tabaroun*

constituted the total sample from the present population of the State of Bahrain: 498 males “46.2%” and 579 females “53.8%”. *Mu'tabaroun* were divided to seven age groups “Table 1”. Additionally, they were divided to five educational levels “Table 2”. Other variables such as occupation, geographical distribution, and socioeconomic level were also considered.

***I'tibar* or test**

Ibn al-Haytham used the term *I'tibar* for experiment and test. In the present study we use the term *I'tibar* as a test which includes five experiments. He verified empirically his theory of *aghlat al-basar* or error of vision and his *I'tibar* or test. He put the mathematical as well as the geometrical basis of his psychological test “Khaleefa, 1999”.

He wrote: "Take a light-weight wooden board of a pale color, one cubit in length and four fairly large digits wide. Its surface should be even and smooth and its longitudinal and latitudinal edges should be parallel. Draw two intersecting diameters on it and from the point of intersection draw a straight line parallel to its length and another straight line perpendicular to the first, middle line. Paint these lines in different bright colors to make them visible, and paint the diameters in one color. In the middle of the board's shorter edge and at the end of the middle straight line between the diameters, make a round but narrowing opening whose wider part at the beginning is large enough for inserting the bridge of the nose so that the board may rest upon it in such a way that the board's corners will be extremely close to the middles of the eyes' surfaces, so close in fact that they almost touch them without actually doing so" “p. 238” “see the diagram in the appendix”.

He continued: "Let the board be like the figure ABGD “Appendix 2 shows a diagram of the test”: the diameters are AD, BG; the intersection point is K; the longitudinal line extending in its middle is EKZ; the line intersecting this line at right angles is HKT; and the opening in the middle of the board's latitudinal side is contained by the line MEN". He added "Once the board has been prepared and the lines have been drawn in it in this manner, take a small piece of white wax and make three small cylindrical objects out of it and paint them in three different colors; place one of

the objects in the middle of the board at point K; fasten it there so that it cannot be removed from this position and let it stand upright on the board; place the other two objects at the ends of the transverse line, at points H, T; the three objects will lie on one line"

He added: "The experimenter should then raise the board and , placing the opening in the middle of its side on his nose, insert the bridge of his nose in it so that the corners of the board will be close to touching the middles of the surfaces of the eyes. The experimenter should then endeavor to look at the object in the middle of the board, fixing his gaze intensely on it. When the experimenter does this, the axes of the two eyes will meet on that object and either coincide with or be parallel to the diameters; the common axis we have already defined will coincide with the line extending through the length of the board “p. 239”. In the present study we have replicated five experiments of Ibn-Hytham as described below.

Experiment 1

With both eyes focused on the object at K, the point in which the common axis EZ cuts the transverse line HT at right angles:

(1)The two objects at H and T, and all points on HT, are seen single; the line HT appears as a single line; and

(2)The line EZ is seen as two lines that intersect at K, and so is each of the diameters AD and BG.

Experiment 2

With the eye fixed on the object at H or at T- a case in which the visual axes are not symmetrically situated with respect to the common axis EZ.

(1)The objects at H, K, T, and all points on HT, are seen single; the line HT appears as a single line; and

(2)The line EZ, and each of the diameters AD and BG, are seen double.

Experiment 3

With two objects at L and F on the common axis EZ (=c), before and after K, respectively, and with the eyes focused on K:

(1)The two objects appears as four- two over to the right, and two over to the left; and

(2)Each of the four objects "i.e. images" appears on one of the two lines into which c has been doubled.

Experiment 4

Three cases are considered:

(a)With the eyes fixed on K and the objects O1, O2 placed at two points on one of the diameters, then on the other, one object, O1, before, and the other, O2, beyond K: Each of the two objects, and each of the diameters, appears double.

(b)`With the eyes fixed on K, and the objects O1, O2 placed on the near segments of the diameters: The two objects appear as four-two closer together, and two farther apart.

(c)With the eyes fixed on K, and the two objects placed on the far segments of the diameters: The two objects appear as four, as in case (b), two closer together and two farther apart.

Experiment 5

The eyes are fixed on the middle object at K while regarding an object placed, first, at a point I beyond H but very close to it, then at a point Q farther away from H- both I and Q being on the right edge of the board: The object appears single when regarded at I, and double when regarded at Q.

The replication

In the present study we employed Ibn al-Haytham's *I'tibar* or test. He specified clearly the length of his psychological test as '*looh min khashab'* or a wooden board, according to the measure of his time: "One cubit in length and four fairly large digits wide". In Arabic we read "*Tolaho qadr*

a'zm al-dhira' wa a'rdaho arba' asabi' mogtadirah". According to Nazif "1942" the lengths of cubit and four fairly large digits are 50 and 8 centimeters, respectively. A renewed and revived *looh* or wooden board had been designed to be 50 X 8 cm *musfar alloon* or "pale color", *amlas* or "smooth" and its "*nihayata tolaihi wa a'rdaho*" or "longitudinal and latitudinal edges" were *mutawaziyain* or "parallel". We have drawn all *khotoot* or lines and *asbagh* or paintings in the *looh* or board according to Ibn al-Haytham description. *Khargan mustadiran* or the round and narrowing point for the board has been designed to be 2 X 3 cm for adults and 2 X 2.5 cm for children "Appendix 1 shows a diagram of the test".

Ibn al-Haytham "p.238" specified the size of *zawaya* or angles in a broad description. We have tried to convert these measures to modern ones. The angles of HBI, IBQ and QBG were 11, 30 and 36 degrees, respectively. We have tried to make *thalatha ashkhas sighar ostowaniya* or "three small cylindrical objects" from *al-shama' al-abyad* or white wax as Ibn al-Haytham mentioned. However, we have some problems with this, including the design, size and color. Additionally, Ibn al-Haytham said that these objects were fastened *hatta la yazol min mawdi'hi* or "so that it cannot be removed"; this was very difficult to be achieved. The objects that we made from wax were unsatisfactory. For these reasons we used three pin objects similar in function to the shape, size and color "green, blue and red". Pins are sharp and stand steadily in the wooden board without movement.

Procedures

The reconstructed test was applied individually for *mu'tabaroun* or participants at their homes by trained students from the University of Bahrain. Suitable physical and social conditions were created for the administration of the scale. *Mu'tabireen* or examiners explained the purpose of the study to all participants. Clear instructions were given to and results were written in the record forms. One problem which faced *mu'tabireen* was that some *mu'tabaroun*, particularly those who were more than 50 years old and illiterate, are *"yatamalaloon*" or get bored with the test. However, there was a good response from younger participants "10-30 years". Another

problem was that administration of the test required full "*tahdiq*" or gazing, contemplating and fixing of the two eyes on the specified objects and lines according to Ibn al-Haytham's instructions. Some participants found it difficult to do that “Appendix 2 shows how the test was placed on the nose”.

Results

Ibn al-Haytham's results

Ibn al-Haytham “p. 240” found that: in the figure ABGD, draw lines BH, BI, BQ; lines HB will be greater than line BT, but line HK is equal to line KT; therefore, angle TBK is greater than angle KBH. But angle TBK is equal to angle HAK, therefore, angle HAK is greater than angle HBK. Therefore, the distance of line AH from the axis AK is greater than that of line BH from the axis BK, but the difference between the two distances is small because the difference between angles HAK, HBK is small. Now the objects at point H is always seen with both eyes as one if the two axes meet on the object at point K; and lines AH, BH as in the same direction as the two rays proceeding to the object at point H, if the axes meet on the object at point K.

He added: "While in this situation, the experimenter should contemplate every-thing on the surface of the board. He will see each of the three objects at points H, K and K single, and will also find line HKT to be one. But line EZ, which extends through the length of the board, will appear as two lines intersecting at the middle object. Similarly, when contemplating the diameters while in this situation, he will find them to be four, each of them appearing double".

Further: "It is clear from this case that an object opposite the middle of one eye and displaced from the middle of the eye will be seen double. For the form of the point that occurs in the middle of one eye will proceed to the Center, whereas the form of the point that is displaced from the middle of the other eye will occur in a point other that the Center and its displacement from the Center will be according to the point's displacement on the surface of the eye".

"It is clear evident from all the experimentation we have described and from our explanation, that the object on which the two axes meet is invariably seen single; that an object will also be seen single if the rays that meet on it lie in the same direction and there is no great discrepancy between their distances from the axis; that an object will be seen double if the rays that meet on it have the same direction but differ greatly with respect to their distant from the two axes; that an object will be seen double if it is perceived through rays of different directions through their distances from the two axes may be equal; and that all this will be so long as the two axes meet on a single object. We have now shown, both by reasoning and experiment, the reason why each of the familiar objects is seen single by both eyes "pp. 241-242".

The present Results

(1) How well does Ibn-Haytham's test replicate at the beginning of the 21th century?

The most remarkable finding of the present study is that his 11th century results replicates to 78.2% by the measures under modern conditions.

(2) What is the mean of performance of the different tests?

The study showed that the average performance of *mu'tabaroun* in all five experiments of the test was 3.91 "SD=1.06" out of a possible total of 5. There are some differences between means of these experiments "Table 3".

(3) What is the influence of age on *aghlat al-basar* or error of visions?

The study showed that error of vision decreases with the increasing of age "Table 1".

(4) What is the influence of gender on *aghlat al-basar*?

The study showed means 3.86 for females and 3.97 for males. Males were more susceptible to error of vision than females "Table 4".

(5) What is the influence of education on *aghlat al-basar*?

The study showed that errors of vision increase with education but decrease slightly during secondary and university level "Table 2".

(6) What is the interaction between age and education on *aghlat al-basar*?

The study showed that there was an interaction between age and education. With increasing of age errors of vision decrease and with the increasing of education it increase too “Fig. 1”.

(7) What is the reliability of Ibn-Hyatham test?

Ibn-Haytham experiments were applied to a group of 60 *mu'tabaroun* for test-retest reliability. The correlation between the first and second application was +.92. The reliability coefficient for alpha was +.96, and the standardized item alpha was +.96. Guttman split-half reliability of the test was +.88, and the reliability given by the equal length Spearman-Brown test was +.88.

(8) What is the validity of the test?

The correlation coefficient between Ibn al-Haytham Form 1 and Ibn al-Hyatham Form 11 was +.81. Form 1 consisted of 24 positions or points while Form 11 of 10 points.

Discussion

Naturally, there are some difficulties in discussing an experiment whose description data from the 11th century. A part from anything else, Ibn al-Haytham's treatment of vision was a form of *tarkib*, or a synthesis of physics, geometry, mathematics and psychology. which reveal that it is unlikely that any simple model can account for all visual illusion, we will compare Ibn al-Haytham's original results and those of our replication with a number of similar modern studies.

Ibn al-Haytham grasped that *aghlat al-basar*, or error of vision, is an unavoidable psychological perceptual phenomenon. Thus, we may analyze his study in both old and current psychological terms. Hilgard, Atkinson and Atkinson “1979” wrote in their well known" Introduction to psychology" that for the most part, our perceptions serve us very well. Most of the time, seeing is believing. However, our perceptions do fail at times, and such failures provide important clues about how the perceptual process works. Hence, in the study of perception, psychologists have turned to illusions, in which perceptions are misleading, in order better to

understand the process. Psychologists have studied geometrical illusions for many years but still do not totally agree on their explanations. Some illusions are based on relative size in contrast with surroundings, other may be understood if we suppose the figures to be projected in the third dimension.

The overall finding of the present study indicated the accuracy of Ibn al-Haytham test at 78.2% with a difference of only 0.2. This finding confirms our first study with Form 1 of the test, which showed 78% accuracy. These findings gave strong support to Ibn al-Haytham's doctrine on *aghlat al-basar* or errors of vision. There are several explanations which can be made for the accuracy of this ancient psychological apparatus; and the difference between the expected degree "100%" and the actual one "78.2%" can be related to several factors. One factor might be the differences in detail of the apparatus such as using pins instead of wax objects and variation in colors.

Another factor is that some ma'tabroun found it difficult to follow Ibn al-Haytham's terms, such as *tahdiq* "focusing" and *qotr "*diagonal". Also, many *mu'tabaroun* became *yatamalaloon,* or bored with the procedure. This is quite consistent with the conclusion reached by Omar "1981" that one of the important characteristics of Ibn al-Haytham's method was that he repeats the observations of any phenomena under investigation. He did not accept any theory without numerous and frequent observations in order to prove its validity.

Ibn al-Haytham interpreted his psychological study regarding *aghlat al-basar* in terms of differences of angles and lines during *tahdiq* or focusing. Many psychologists to day also discuss visual illusions in terms of variations in angles "Allport & Pettigrew, 1957; Dodwell, 1981; Gregory, 1968". One of the most striking aspects of regularity is the presence of right angles in the artefacts and the overestimation of acute angles "Derogowiski, 1980".

Ibn al-Haytham wrote: "Similarly, with the object at point I: the rays proceeding to it will have the same direction as lines AI, BI, and it will be seen single. Angles IAK, IBK, too, will not differ greatly, because angle HBI will have no sensible magnitude if point I lies very close to point

H. From this it is clear that an object on the same side of both axes will be seen single with both eyes, provided that no great discrepancy exists between the distances of the rays drawn to it from the two eyes. But angles QAK, OBK, are appreciably different; and the object at point Q is seen double when the two axes meet on the object at point K. It is therefore clear from this that when the positions of the rays drawn to an object from the two eyes differ greatly with respect to their distance from the axes, then that object will be seen double, even if it is situated on the same side of both axes" “pp. 240-242”

Ibn al-Haytham has also interpreted his psychological study in terms of size constancy, which equates to constancy of scaling in current psychological studies “Fisher, 1968; Gregory, 1963, 1966, 1970; Schiffman, 1982; Thiery, 1896 “. He argued that sight might also mistake the *size* of an object for the reason that the object's distance has exceeded the moderate range. Thus an object perceived from an excessively great distance will appear smaller than its real size. And since size can be perceived only by inference, this will be an error in that inference". As he put it: "The reason why sight perceives as object at an excessively great distance to be smaller than its real magnitude is that the size of an object is perceptible only by estimating the object's size by the angle of the cone that surrounds it together with the magnitude of the object's distance “p. 284”.

One remarkable finding of the present study is that *aghlat al-basar* or errors of vision decrease with the increase of age. Young *mu'tabaroun* are more susceptible to illusion than to elder ones. This result is similar to Khaleefa and Manaa' “2000, 2001” studies with regard to Form 1 of Ibn al-Hytham test. It also supports those of many contemporary psychologists that children have higher scores on illusion than adults “Derogowiski, 1980; Segall, Cambell, & Herskovits, 1966; Wagner, 1977”. Several explanations can be suggested for understanding this. Lack of attention and concentration with increasing of age may be one factor.

Cognitive components that contribute to perceptual distortions include such as those supposed in the perspective-consistency mechanism and, in general, the incorporation of depth cues in perceptual judgement. Other cognitive-type factors may involve attention, attitude and past

experience “Schiffman, 1982”. Attention especially may be one factor that may influence the susceptibility of illusion “e.g., Davis, 1970; Derogowiski, 1980; Jahoda & Stancey, 1970”.

The study showed that *aghlat al-basar* increases with increasing education on Ibn-Haytham test. Illiterate *mu'tabaroun* showed fewer errors of vision compared to literate ones while those with university education have high scores. This result supports the results of our study of Form 1 of Ibn al-Hytham test. Many investigators in contemporary psychology showed that education increases attention “e.g., Derogowiski, 1980; Jahoda & Stancey, 1970”: more *tahdiq* or focusing. Psychological studies have shown that groups differing in education differ also in the way in which they react to exposure to new stimuli and perhaps to the very task of being tested “Derogowiski, 1980”.

Our result contradicted the conclusion reached by Jahoda that education tends to reduce illusion. Also, it contradicted Derogowiski's finding that the more educated subjects adapt to such a situation with greater ease and therefore the decline of the illusory effect, which is associated with repeated presentation of the stimulus, begins, in their case, relatively early. The less educated do not adapt as easily and the decline, if any, is therefore retarded “Derogowiski, 1980”. One might argue that *aghlat al-basar* as measured by Ibn al-Haytham's experiments is a form of secondary illusions in which the magnitude of such illusion typically increased to a certain degree “cf Piaget, 1969”.

Possibly illusion decreases with education in simple geometrical shapes, such as the Muller-Lyer, Ponzo and Vertical-Horizontal, while it increases with education on complex ones such as Ibn al-Haytham's test, which relies on binocular vision. Khaleefa and Manaa (2000) found that when covering one eye there is no error of vision in Ibn Al-Haytham test. Empirically, in Bahrain, all one-eyed individuals or *awar* or one eyed *mu'tabaroun* have no error of vision. Additionally, their study showed that attention improves binocular vision, whilst, lack of attention increases illusions such as the Muller-Lyer and Ponzo. More theoretical and empirical studies are needed to differentiate between these possibilities.

Finally, the study showed that the Ibn-Hyatham test was reliable and valid. The reliability of the scale in terms of the correlation coefficient ranged between +.88 to +.92, which is very high. The validity of the scale, in terms of the correlation coefficients between Ibn al-Haytham experiments Form 1 and Ibn al-Haytham Form 11, was +.81. This is a remarkable success for a psychological apparatus that was devised in the 11th century and revived and renewed at the beginning of the 21th century.

Conclusion

Some findings stand out in the present study. From the beginning of *Magala* 1 of *Kitab al-Manazir* in which optics is treated theoretically to the applied psychological topics of *Magala* 11 and 111, Ibn al-Haytham tested his ideas against observation. He displayed pioneering genius in grouping that since the 11 the century that psychological phenomena, such as *aghlat al-basar*, or visual illusions can be studied quantitatively not until the nineteenth century was this insight be achieved. Perhaps, it was the first time in the history of science the concept of *I'tibar* or test was introduced, which can be easily distinguished from other methods of investigation. He not only formulated new theories and pioneered a new approach, he also devised his own apparatus to test them. Our replication of his studies of *aghlat Al-basar* or visual illusions come to underline how advanced his thinking and practice were. His long neglected work deserves detailed study by all those interested in the history of measurement in psychology.

Table (1) Summary of Means and SDs for the Age Groups

Age group	Mcan	SD	Number
1-10	4.20	0.83	25
11-20	4.16	1.05	258
21-30	4.11	1.14	254
31-40	3.86	0.93	200
41-50	3.82	0.92	179
51-60	3.42	0.97	123
61-70	2.86	1.08	32
Total	3.91	1.06	1077

Table (2) Summary of Means and SDs for Educational levels

Educational level	Mean	*SD*	Number
Illiterate	3.23	1.04	160
Primary Education	3.77	1.02	176
Intermediate	3.92	0.80	170
Secondary	4.11	1.21	342
University	4.18	0.69	229

Table (3)

Summary of means and SD for five experiments of the test

experiment	Mean	SD
1	0.91	0.26
2	0.81	0.35
3	0.70	0.36
4	0.62	0.36
5	0.87	0.51

Table (4)

Summary of Means and SDs for Gender and the Entire Sample

Gender	Mean	Variance	Number
Male	3.95	0.99	498
Female	3.86	1.21	579

References

Allport, G., and Pettigrew, T. (1957). Cultural influences on the perception of movement: The trapezoid illusion among Zulus. *Journal of Abnormal and Social Psychology*, 55 , 104-120

Boring, E. (1957). *A history of Experimental Psychology*. New York: Appleton-Century Crofts.

Davis, C. (1970). Education and susceptibility of the Muller-lyer illusion among the Banyakole. *Journal of Social Psychology*, 82, 25-34.

Deregowski, J. (1967). The horizontal-vertical illusion and the ecological hypothesis.*International Journal of Psychology*, 2, 269-273.

Deregowski , J. (1980). *Illusions, Patterns and Pictures: A cross Cultural Perspective* . London: Academic Press.

Dodwell, P. (1981). *Pattern and object perception*. In Handbook of perception, vol. V: Seeing "267-299" edited by E. Carterette and M. Friedman. New York: Academic Press.

Fisher, G. (1968). An experimental and theoretical appraisal of the inappropriate size -depth theories of illusions. *British Journal of Psychology*, 59, 373-383.

Gregory, R. (1963). *Distortion of Visual Space as inappropriate consistency scaling Nature*, 199, 678-680.

Gregory, R. (1966). *Visual illusions*. In New Horizons in Psychology. Edited by B. Foss. Baltimore: Wiley.

Gregory, R. (1968). *Eye and Brain*. London: World University Library.

Gregory, R. (1968). Visual illusions. *Scientific American*, 219, 66-76.

Gregory, R. (1970). *The Intelligent Eye*. London: Weidenfeld and Nicholson. Hilgard, E., Atkinson, R., Atkinson, R. (1979). Introduction to Psychology. New York: Harcourt.

Howard, I. (1996). *Alhazen's neglected discoveries of visual phenomena. Perception*, 25, 1203-1217.

Howard, I., and Rogers, B. (1995). *Binocular Vision and Stereopsis*. New York: Oxford University Press.

Ibn al-Haytham (1983). *Kitab al-Manazir*. Edited with introduction, concordance tables, by A. Sabra. Kuwait: The National Council for Culture, Arts, and Letters.

Ibn al-Haytham (1989). *The Optics of Ibn al-Haytham*, Books 1-111, Trans. With introduction and commentary by A. Sabra. London: The Warburg Institute.

Ibn Sina "980-1037". *al-Shifa'*, edited by G. Qanawati & S. Zai'd. Cairo: al-Haya' al-Masriya lil-Kitab, 1975.

Jahoda, G., Stacey, B. (1970). Susceptibility to geometrical illusions according toculture and professional training. *Perception and Psychophysics*, 7, 179-184.

Khaleefa, O. (2001). *Experimental Psychology in the Arab Islamic Heritage* (in Arabic). Beirut: Arab Institute for Research and Publishing.

Khaleefa, O. (1999). Who is the founder of psychophysics and experimental psychology? *The American Journal of Islamic Social Sciences*, 16, 1-26 (USA).

Khaleefa, O., & Manaa, H. (2001). Ibn al-Haytham studies of visual illusions: New discoveries in the history of experimental psychology. illusions. *Umm Al-Qura University Journal*, 13, 19-48 "Saudia Arabia".

Khaleefa, O., & Manna, H. (2000). Ibn al-Haytham studies of visual illusions: New discoveries in the history of experimental psychology. *International Journal of Psychology*, Abstracts of the xxv11 International Congress of Psychology. Stockholm, Sweden 23-28 July 2000.

Nazif, M. (1942). *al-Hasan ibn al-Haytham*, buhuthuhu wa kushufuhu al-basariyya.

Cairo: Jamia't Foad Al-Awwal.Omar, S. (1981). al-i'stiqra' 'ind Ibn al-Haytham. *Journal of the History of Arab Sciences*, 5 , 75-89.

Piaget, J. (1969). *The Mechanisms of Perception. Tans*. By G. Seagrim. London: Routledge and Kegan Paul.

Sabra, A. (1971). The Astronomical Origin of Ibn al-Haytham's Concept of Experiment.*Actes du Congres International d'Histoire des Sciences, Paris*, T. 111A, 133-136.

Sabra, A. (1983). Kitab al-Manazir. Edited with introduction, concordance tables, by A. Sabra. Kuwait: The National Council for Culture, Arts, and Letters.

Sabra, A. (1989*).* *The Optics of Ibn al-Haytham*, Books 1-111. Translated with Introduction and Commentary by A. Sabra. London: The Warburg Institute.

Segall, M., Campbell, D., & Herskovits, M. (1966). Influence of *Culture on Visual Perception*. Indianapolis: Bobbs-Merill.

Schiffman, H. (1982). *Sensation and Perception: An integrated approach*. 2rd edition. New York: John Wiley & Sons.

Taha, Z. (1990). Psychophysics according to Ibn al-Haytham. *Arab Journal of Psychiatry*, 1, 256-273.

Thiery, A. (1896). Uber geometrische-optische tauschungen. *Philosophische Studiern*, 12, 67-126.

Wagner, D. (1977). Ontogeny of the Ponzo illusion: Effects of age, schooling and environment. *International Journal of Psychology*, 12, 161-176.