Why Did Geometrical Optics not Lead to Perspective in Medieval Islam?

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Rationality and Good Reasons in the Anthropology of Mathematics

Dominique Raynaud*

In the foreword to his *Studies in the Sociology of Religion*, Max Weber questions the conditions under which many cultural phenomena appeared as Western singularities, but nonetheless took a universal value (Weber, 1922). He wonders in particular about the rise of linear perspective in the West. His general solution to the problem is based on the idea of a 'rationalization process' that grows up in determinate societies, and gradually pervades all human activities, according to the particular conditions men meet or create. Taking the perspective problem anew, it has been shown that the favourable conditions reputed to be specific to Renaissance go back in fact to the Medieval optical literature that played a prominent role in the rationalization of sight (Raynaud, 1998). There are many clues of this contribution, such as the borrowings and explicit references that are to be found in the treatises by Alberti, Piero della Francesca, Ghiberti, or Vinci, to begin with. But, on the other hand, a growing number of critical editions of Arabic optical literature now enables us to see that the Latin optical treatises, the Renaissance scholars relied on, comment thoroughly Arabic optics. As a result, we must recognize a second-order continuity between Renaissance and Medieval Arabic achievements that put forward new and specific questions.

The problem I want to put into consideration is the following: if Renaissance perspective proceeds from Medieval Latin optics, whose contents go back to Arabic optics, we could then expect the first stages of perspective advancement to be found in the Arabic civilization. But there is nothing to confirm this deduction, because in all the areas where Arabic was spoken—so including Persia, Central Asia, or al-'Andalûs—painting, miniature, and technical diagrams were drawn according to other types of representation: frontal and oblique projections, for the most part. So how to explain that first rank optical researches grew up in Islam without any application to representation? Is it the consequence of a decisive improvement of optical knowledge after been transplanted into Latin World? Is it due to the sparse diffusion of optical treatises in Orient? Is it a consequence of the well known Islamic aversion for images? The fact is unclear, and requires a new sight. After having detailed the nature and soundness of optical knowledge tied to perspective questions (Part I), I will scrutinize three sets of reasons: sociability, religious beliefs, and axiological orientation of those who were the potential users of perspective in Islam (Part II).

Part I. Arabic Theoretical Knowledge on Perspective

This section is devoted to establish that all optical sources that were actually combined to give birth to linear perspective were yet available in Medieval Islam.

Before establishing the point, I will say few words of the four main texts that will intervene in the course of the demonstration: (1) Euclid's *Optics* was translated into Arabic by Hiliyâ b. Sarjûn—a scholar of Greek origin as his name tell us: 'Elias filius Sergii'. His *Kitâb Uqlîdis fî ikhtilâf al-manâẕir (Book of Euclid on the Difference of Perspectives)* dates from ca. 212 H. / 827-28 (Kheirandish, 1999); (2) Among other optical works, al-Kindî wrote a *Book on the Rectification of the Errors and Difficulties dues to Euclid in his Book of Optics (Kitâb Abî Yûsuf Ya'qûb b. Isẖâq al-Kindî ilâ ba'ḏ ikwânihi fî taqwîm al-khaṯa' wa al-mushkilât allatî li-Uqlîdis fi kitâbihi al-mawsûm bi-al-manâẕir).* Composed before 866, this treatise is important to apprehend the shift between al-Kindî's optics and the Euclidean tradition, to which he nevertheless pertains (Rashed, 1997); (3) Qusṯâ b. Lûqâ was a friend and a collaborator of al-Kindî. He also undertook studies in optics, and wrote a treatise entitled *The Book on the Causes of the Difference of Perspectives that appear in the Mirrors (Kitâb fî 'ilal mâ ya'riḏu fî al-marâyâ min ikhtilâf al-manâẕir)*. This treatise is searching out in the direction of a geometrical-physiological synthesis. Being dedicated to al-Muwaffaq (229-78 H. / 843-91), it is posterior to al-Kindî's works, possibly ca. 870 (Rashed, 1997); (4) Finally, no study can ignore Ibn al-Haytham's *Kitâb al-manâẕir*. In his masterpiece of optics, Ibn al-Haytham champions intromissionism and sensorial image *(ṣûra)* against Euclidean visual ray theory and Ptolemy's emissionism. Being included in the List III transmitted by Abî Uṣaybi'a in his *Ṯabaqât*, the treatise was composed between 419-29 H. / 1028-38 (Sabra, 1989).

The Perspective of the Circle

Ibn Sarjûn: "Wheels of chariots are seen at times as circular and *at other times as distorted (*)*. Let then be a wheel, ABGD, and we draw in it two diameters, AB, GD, intersecting at right angles at point E; and let the eye be on a plane parallel to the plane of the circle. Then if the line drawn from the eye's position to the circle's centre is perpendicular to the circle's surface, or else equal to half its diameter but not perpendicular, then the diameters are seen equal; therefore it is demonstrated that the wheel is seen as circular; but if the line drawn from the eye's position to the circle's centre is not perpendicular to the circle's surface and not equal to half its diameter, *then the diameters are seen as unequal; therefore it is demonstrated that the wheel is seen in this case as distorted (*).* And that is what we wished to demonstrate" (**Fig. 1**).[1]

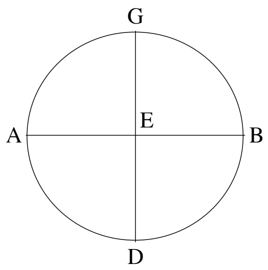


Fig. 1

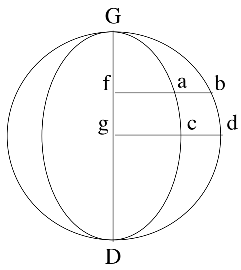


Fig. 2

Al-Kindî: "The wheels of a chariot *during his moving (**)* are seen at times as circular, at other times as non circular […] Demonstration: if the line drawn from the eye to point E, that is the centre of the wheel, is perpendicular in E to lines AB and GD, then all diameters belonging to it are seen equal, and the wheel AGBD necessarily appears as circular […] If the line drawn from the eye to point E is neither perpendicular to the circle's plane AGBD, nor equal to its semi-diameter, then the diameters cutting the circle are seen as different. It is then clear, for that reason, that wheel AGBD will be seen as non circular. And this happens for all circle and all circular figure: if the line drawn from the eye to his centre falls either perpendicularly to the circle's plane, or non perpendicularly but being the line equal to the semi-diameter of the circle, the circle is seen, for that reason, circular, and if this line is unequal, *it will be seen deviated and non circular (***)*. And that is what we intended to demonstrate" (**Fig. 1**).[2]

Commentaries. * The Arabic version of Euclid's *Optics* deals here with the problem of how a circle is seen in perspective. According to the eye's position, a wheel, as any other circular figure, will appear circular when the visual ray falling on the centre of the circle is perpendicular to the circle's plane; elliptical otherwise. Ibn Sarjûn and al-Kindî use the words * *mu‘awwaj* 'distorted' and *** *man<u>h</u>ir* 'deviated', instead of *nuq<u>s</u>ân* 'ellipse, lack', to refer to the appearance of the circle. So they describe the ellipse by the angle formed by the visual ray falling on the centre of the circle and the line perpendicular to the circle's plane, what presupposes an affine transformation $K = fa / fb = gc / gd$ (**Fig. 2**). This geometrical property was known from Archimedes' *Conoids and Spheroids*, prop. 4 (1970: 166-170) and Ibrâhîm b. Sinân expound it his *Maqâla fî rasm al-qu<u>t</u>û‘ al-thalâtha (Epistle on the Drawing of the Three*

Sections) (Rashed and Bellosta, 2000: 263-89). ** Al-Kindî's *Rectification* usefully complements the proposition, insisting the on continuity in experiencing the various perspectives of a circular figure. The point is made clear, in considering the rectilinear movement of a chariot passing along the spectator. Renaissance scholars will gradually put in evidence that a circle is always seen as a conic section—generally an ellipse—and that it can be obtained by an affine projection (Vinci, *Codex Atlanticus*, fol. 115rb, ca. 1510). This fundamental law of perspective was yet a source of geometrical interest, before the Xth century.

Intersecting the Visual Pyramid

Ibn Sarjûn: "[Of] planes below the eye, the most distant one is seen at the highest. For let the eye's position be point A, which is higher than plane BDEF, and let the ray[s] AB, AD, AE, AF fall. Then I say that FE is seen higher than ED, and ED [is seen] higher than DC. So let us cut line BD in half at point C, and draw GC at a right angle. *Now because the visual ray falls upon GC (*)* before falling upon CF, then ray AF falls upon line GC at point G, and ray AE [falls] at point H, and ray AD [falls] at point I; then all the rays fall upon line GC; but because point G is higher than point H, and point H is higher than point I, and the ray that has point G on it [also] has point F on it, and the ray that has point H on it [also] has point E on it, and the ray that has point I on it [also] has point D on it, and since FE is seen because of GH, and ED is seen because of HI, then FE is seen higher than ED, and in the same way, ED is also seen higher than DC. And that is what we wished to demonstrate" (**Fig. 3**).[3]

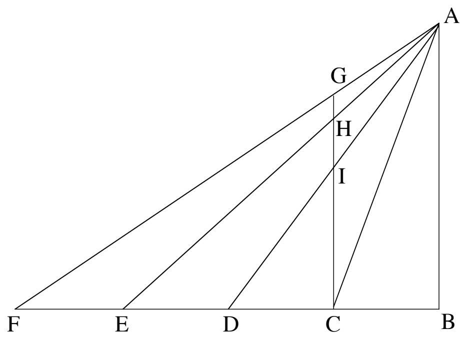


Fig. 3

Al-Kindî: "Among surfaces disposed below the eye in the same plane, the most distant from the eye are seen higher than the nearer from eye […] Demonstration: Draw a line from A to B, and lines AF, AE, AD, AC, that we suppose to be the [visual] rays. The size they enclose is what the ends of the ray encompass. The ends of the ray under which we see EF are the two lines AF and

AE, the ends of the ray under which we see DE are the two lines AD and AC and the ends of the ray under which we see CD are the two lines AC and AB. *Draw a perpendicular at point C towards point G on AF, and mark point H where line GC cut line AE, and mark point I where line GC cut line AD (*)*. Then point C is seen by line AC and point D is seen by line AID; from A we see point H higher than point I according to the size of line IH. But point E is seen from A by line AHE, therefore point E is seen more deviated upwards, *depending on the size of line IH (**)*. But point F is seen at the same time that point G, therefore ray AGF is higher than H depending on the size of line GH; therefore point F is seen higher, i.e. more deviated in the direction of A than point H, *depending on the size of line HG (**)*. Therefore it is seen higher than E by line HG. As a result F is seen more deviated upwards than E, and E more deviated than D, and D more than C, and C more than B, by the same way. Therefore most distant places and surfaces, having all their width on line BF, are seen higher, i.e. more deviated in the direction of A, than the points of line BF nearest to A. And that is what we intended to demonstrate" (**Fig. 3**).[4]

Commentaries. * Ibn Sarjûn and al-Kindî use explicitly the system known as the 'intersection of the pyramid of visual rays' in which picture plane GC intersect visual rays AF, AE, AD, AC… This is nothing but the definition of linear perspective given by Alberti (1992: 103), Vinci (1970: 34), or Danti (2003: 119, def. I). **, *** Al-Kindî goes beyond the Arabic version of the *Optics* for where Ibn Sarjûn considers only the position of segments GH, HI, IC (higher or lower), al-Kindî estimates the length of segments ("point H is seen higher… depending on the size of line IH"). So al-Kindî was perfectly aware that GH < HI < IC. But being line GH the picture plane, and expression as "size of line IH", "size of line HG" referring to the size of visible things, we must conclude that, from the IXth century, Arabic scholars knew how to size the diminution of the receding intervals, bringing forward the material required by linear perspective (Alberti, 1992: 121; Francesca, 1984: 85, prop. XXII, Danti, 2003: 188, th. XXIII). Even if Arabic scholars did not think about the practical consequences of this result, it was yet ascertained by way of demonstration.

The Route to the Vanishing Point

Al-Kindî: "*The intervals between two parallel lines are seen unequal; what is remoter from the pupil is seen narrower, and what is closer to the pupil is seen larger (*)*. Suppose AC and BD to be the two parallel lines; suppose C to be near D, and let be E the position of the pupil […] Let be the intervals AB, FG, HI… Demonstration: AB is seen from E under angle AEB, the largest one; FG is seen from E under angle FEG which is smaller than angle AEB; and HI is seen from E under angle HEI which is smaller than angle FEG. Therefore AB is seen larger than FG and FG is seen larger than HI, for what is seen under a large angle is seen larger, and what is seen under a small angle is seen smaller. But the ends of the largest interval are seen more distant than the ends of the smaller one. Therefore the two points A and B, that are closer to the pupil, are seen more distant than the two points F and G, that are remoter from the pupil. By the same way, we demonstrate that the two points F and G are seen more distant than the two points H and I [...] *Therefore if the pupil is set on point E, the two points A and B are seen more distant than the two points K and L (*)*. And that is what we intended to demonstrate" (**Fig. 4**).[5]

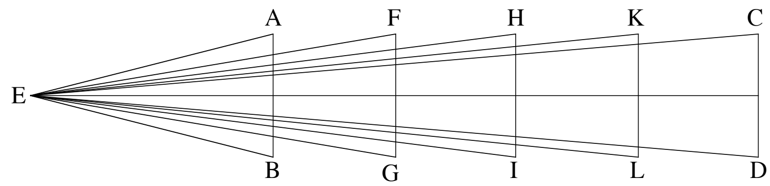


Fig. 4

Qusṯâ b. Lûqâ: "By which reason the same object appear to be of an unequal size, when getting closer or moving away from the eye? It will be seen larger when getting closer, smaller when moving away [...] Let be line AB the visible object, point E the seeing eye, and let be AEB the cone of rays spreading from the eye. *Move the visible object AB from position AB to FG (**)*, then the ray that spreads from the eye, which is at point E, up to this object, is cone FEG; therefore the visible object is seen as FG under angle FEG. But angle FEG is smaller than angle AEB, therefore FG is seen smaller than AB. *Move now the visible object from FG to HI (**)*, it will be seen under angle HEI, which is smaller than FEG. *Imagine the visible object to be remove from HI to KL (**)*, it will be seen under angle LEK, which is smaller than HEI. Therefore KL is seen smaller than HI. *Similarly, if we move the object from KL to CD (**)*, then it will be seen under cone CED, and so will appear smaller than KL. Similarly, as the visible object moves away from the eye, the angle under which is seen is smaller and smaller. If the narrowing goes up to the limit that the angle is a line without breadth, the visible object which is the base of this angle will not be seen, due to its narrowing. The visible object goes on diminishing, according to the diminution of the angle, *till becoming so small in size that the visual sense cannot perceives it no more (***)*" (**Fig. 4**).[6]

Commentaries. Here al-Kindî and Qusṯâ b. Lûqâ deal with (Euclidean) fundamental law of perspective, that an object becomes smaller and smaller as it recedes from the eye. * Al-Kindî proves the property geometrically. He establishes that equal lines GF, IH, LK, DC, cut out different angles of vision, according to the distance of the eye. Qusṯâ b. Lûqâ goes beyond this basic result. ** He considers that a single object, AB, moved away from the eye, takes the successive positions GF, IH, LK, DC. Thinking a continuum, Qusṯâ had no reason to stop at DC. *** He thus considers AB is moving away to infinity. This makes a notable difference with al-Kindî because, if the angle tends to zero, the object reduces to a point, and remaining perpendicular to the axis of vision E, it will keep the axis. But a point belonging to the axis of vision is nothing but the 'vanishing point' *(punto centrico, punto principale)* in Renaissance perspective. Even if the concept does not appear in Arabic optics, everyone can verify the striking similarity that exists between Qusṯâ's reasoning and diagram, and those of Piero della Francesca (1984: 73-74, prop. XI), Leonardo da Vinci (1970: 35, 59-61), and Danti (2003: 194, th. XXVII).

Experiments with the Camera Obscura

Al-Kindî: "This [the rectilinear propagation of rays] will be still more evident and clear if we *take a board and make a hole perpendicularly and regularly in it with a saw (*)*; if we then place the centre of the aperture made with a saw and the centre of a candle opposite each other, so that the line drawn from the candle cut orthogonally the candle's diameter and the aperture made with a saw; and finally if we place behind the opened board another board, the surface of which being opposite and parallel to the first board… For instance, let be circle ABG the candle, board DE the perforated board, and space UZ the aperture. And again, let be HT the board on which the light is falling, and let be space KL the part of the board the light is falling on. If therefore we draw a line from point K to point U, and extend it by a straight line, it will fall on point G of the candle, which is *on the side opposite to Z (**)… Definitely, that would not happen if the limits of rays did not follow straight lines (***)*" (**Fig. 5**).[7]

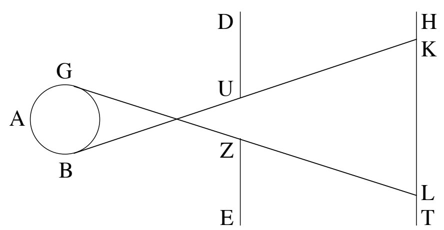


Fig. 5

Ibn al-Haytham: "We also find that the radiation of all lights takes place *only in straight lines and that no light radiates from a luminous object except in straight lines (***)*—provided that the air or transparent body between the luminous object and the body on which the light appears is continuous and of similar transparency. When this state of affairs is examined at all times it is found to be uniform, suffering no variation or change… As for the light of the sun, when it [any light] *enters through a hole into a dark chamber (*)* … the light will appear to extend rectilinearly from the hole through which the light enters… And similarly with the light of the stars: for, in a moonless night, let any of the large stars (such as Venus, or Jupiter at its nearer position [to the earth], or also Mars at its nearer position, or Sirius) be opposite a hole giving into a dark chamber: its light will appear in the chamber and will be found opposite to the hole… If he [the experimenter] observes the star for some time until it has moved through an appreciable distance, *its light in the chamber will be found to have moved from its [former] place so as to be rectilinearly opposite the star (**)*. And as the star moves, that light will move, and the light and the hole and the star will always be found to lie on a straight line" (**Fig. 5**).[8]

Commentaries. *,*** Although many scholars credit Ibn al-Haytham with the invention of the camera obscura *(al-bayt al-muẕlim)*, al-Kindî already experimented the rectilinear propagation of light with it. But, being equipped with a large aperture UZ, al-Kindî's camera obscura could only provide with fuzzy, not stigmatic, images onto the screen HT. Unlike his predecessor, Ibn al-Haytham stressed that the narrowing of the aperture reduce the divergence of rays (Sabra, 1989, 1: 17, Prop. I, 3 [14]). It is however unsure whether the instrument was rigouroulsy stigmatic. Camera obscura system is of a keen interest for perspective, because it paves the way to *via instrumentalis*, in which a picture can be drawn without geometrical reasoning. The apparatus by which Brunelleschi presumably depicted the first perspective view in Florence was of this type. Many other Renaissance scholars took up the apparatus on their own, as Vinci (1970: 44-45), Cardano (1550, IV: 107), Barbaro (1568, V: 192), Danti (2003: 433), etc. ** Sabra is right when he writes: "there is no description in I.H.'s *Optics* of a picture obtained by means of a narrow opening… Kamâl al-Dîn, by contrast, has reported observations of reversed coloured images *(suwar)* of clouds and birds on an unlighted white surface placed behind a narrow opening *Tanqîh*, II: 399" (Sabra, 1989, 2: li). But this contrast gains not to be inflated. The image reversal is in fact contained in al-Kindî's and Ibn al-Haytham's records. In the first experiment, the rays issued from points B and G go to points K and L, and cross each other through the first screen. In the second experiment, when the star moves along BG [on the previous diagram], its image moves upside down along KL. There is again a striking continuity of aims and scope from Arabic optics to Renaissance perspective. Vinci, for instance, presents a very similar figure to Ibn al-Haytham's one, and emphasizes the same argument (Vinci, 1970: 45).

To sum up, all the scientific materials required for the setting up of perspective were yet in position, at least since the XIth century. Why then did linear perspective not arise in Medieval Islam?

Part II. Arabic Disregard for Practical Perspective

Although geometry was used for artistic purposes (Özdural, 2000), and although geometrical optics was cultivated at the highest level—including the very sources of what will become the Renaissance standard—, linear perspective did not arise in Medieval Islam. Other types of representation were preferred as parallel frontal and oblique projections. Frontal projection underlies for instance scenes as "Prince and Attendants", from a *Dîvân* by Jâmî illustrated under the Safawids (**Plate 1A**), or "Bahrâm Gûr in the Turquoise-Blue Pavilion" from a *Khamsa* by Nizâmî, under the Safawids (**Plate 1B**). Oblique projection underlies scenes as "Ulugh Beg with Ladies of his Harem" from the Timurid Samarqand (**Plate 1C**), or "Feast of ʻÎd" from a *Dîvân* by Hâfiz, under the Uzbek dynasty (**Plate 1D**). Frontal and oblique projections were also used in scientific and technical literature, for example al-Jazarî XIIth century compendium *Kitâb al-jâmiʻ bayna al-ʻilm wa al-ʻamal al-nâfiʻ fi sinâʻat al-hiyal (Book of Theory and Useful Practice in the Mechanical Devices)* (New York, Metropolitan Museum, Rogers Funds). So, in all representational domains, if craftsmen ever used a compelling system, they chose prevailingly oblique or frontal projection. Three factors—not of equal importance—seem to have determined this choice.

The Sociability Factor: Artisans and Scientists

The relationship between artisans and scientists is poorly documented in Medieval Islam. Saliba (1999) and Özdural (2000) have nevertheless highlighted many points of interest from the mathematical literature itself. The main references to the topics come from two works of Abû al-Wafâ’ al-Bûzjânî (d. 940): the first work is an arithmetic textbook addressed to the bureaucrats and state functionaries (Medovoi, 1960); the second one is a treatise on practical geometry intended for the artisans (Aghayani, 1997). There is also a testimony by Ibrâhîm b. Sinân (908-946) that his treatise on gnomons passed in the hands of an artisan he become acquainted with (Saliba, 1981). Two other references are to be found in the treatises by Abû al-Rayhân al-Bîrûnî (d. ca. 1048): in the first tract, he informs us some makers of astrolabe of his time used precise arithmetic methods, instead of rough craft methods (Saidan, 1977); in the second tract, he describes exact and approximate methods for the calculation of the *qibla*, being the approximate ones designed for the architects and artisans (al-Bîrûnî, 1967). To these sources, we must add some other treatises. The first one is the *Kitâb fî al-jabr wa al-muqâbala (Book of [Calculus by] Restoration and Reduction)* by Abû Kâmil (d. ca. 930). In the second part of the book, Abû Kâmil embarks on the study of pentagon and decagon, two figures of practical interest for the design of geometrical patterns (Yadegari and Levey, 1971). Another valuable treatise is the *Miftâh al-Hisâb (Key of Arithmetic)* composed by al-Kâshî (d. 1429), where some parts of Book IV, Chapter 9 are devoted to the calculation of *qubbas* and *muqarnas* (Dold-Samplonius, 1993, 1996). Nevertheless, the most distinct evidence that mathematicians and craftsmen were joined together appears in two other documents. At the end of an untitled treatise on a geometrical problem involving the solution of a cubic equation, Omar Khayyam (d. 1131) tells us that the incentive to write it came from a question asked to him during a meeting with artisans—possibly in Isfahan (Amir-Moéz, 1963; Özdural, 1995). Two centuries ago, Abû al-Wafâ' wrote his *Kitâb fî mâ yahtâju ilayhî al-sâni' min a'mâl al-handasa (Book on What is Required by Artisans of Geometric Constructions)*. In Chapter 10, he declares he "attended a meeting to which took part craftsmen and geometers that were asked about the construction of a square made of three squares." Such testimonies establish the existence of long standing contacts between the mathematicians and the lower class of craftsmen. And this makes most vivid the paradox that geometrical optics did not lead to linear perspective in Medieval Islam.

But we have to keep in mind that the relationship between artisans and scientists differed greatly in nature, according to the craftsmen the mathematicians addressed to. Astrolabe and scientific instruments makers were generally praised for their ability. So speaks Ibrâhîm b. Sinân in his *Risâlat fî al-ma'ânî al-latî istikhrajahâ fî al-handasa wa al-nujûm (Epistle on the Examination of Difficult Calculus on Practical Geometry and Stars)*[9]. And so speaks al-Bîrûnî in his *Kitâb tastîh al-suwar wa-tabtîh al-kuwar (Book on Plane Projection of Constellations and Countries)*[10]. Other crafts were in a very different situation. The mathematician Abû al-Wafâ' frequently complains about the lack of accuracy of the solutions provided by the artisans. Regarding their geometrical trial and error, he says:

> "All that is used by craftsmen is done without mathematical principle, and therefore cannot be trusted, and causes many errors… There is no doubt that, among all the constructions traced by artisans, the correct ones were borrowed from geometry. Indeed these constructions were imagined and demonstrated by the geometer, and then, by observation, the artisan took them in a superficial way, without thinking about the demonstration of their correctness. That is why artisans indulge so many errors" (Aghayani, 1997: 106, 119).

Similar statements can be found as regards the inscription of regular polygons in a circle, the construction of a square compound of a (non square) number of small squares, etc.

In sum the data are ambiguous, to say the least. On the one hand, the connexion between craftsmen and mathematicians seems to have been a widespread practise in Medieval Islam. And such meetings were probably held to favour the magnificence of the arts, especially under the Buyid (934-1055) and Saljûqid (1037-1194) patronages. On the other hand, this connexion probably gave the best results in instrumental making than in decorative crafts, as mathematicians repeatedly complain about the crude and inaccurate methods of masons and mosaic makers. Had the mathematicians have thought to apply geometrical optics to art, they should not have carried out this task successfully, because of the bad reception of theoretical geometry by craftsmen. This is a first level of explanation of why linear perspective did not arise in Medieval Islam. But this sociological explanation, based on the spreading-and-closing of social networks, is insufficient.

The Religious Factor: Presumed Aniconism

Among the arguments upheld to explain the absence of perspective in the Arabic world, aniconism is the most common cultural history have ever delivered (Grabar, 1973; Critchlow, 1976; Allen, 1988; Callataÿ, 2001). Strictly speaking, the word 'aniconism' refers to the prohibition of images making in Islamic tradition[11]. Nevertheless, this concept is unable to solve the problem we are faced with. This will be clear after some details will be given.

1. Arabic word for image *(s̲ûra)* has multiple meanings. The verb *s̲awwara* means 'to shape, create' and subsequently 'to depict, represent'. And the question of aniconism in Islam is closely linked to the fact that the same word *mus̲awwir* can refer to 'God' or to a 'painter' in line with religious or secular situations. *S̲ûra* always implies the idea that something has been composed or created *(h̲udûth)*, but the word is equally multifarious. It can be rendered into 'shape, form, image, figure, silhouette, or face', according to the context. And that is why some texts are very confusing. The *h̲adîth* : "The house *(al-bayt)* in which there are images *(al-tamâthil)…* will be fled away by the Angels of Grace" (Bukhârî, *Bad' al-Khalq*, b. 17), is in fact compatible with both permissive and restrictive exegeses. The permissive interpretation understood *al-bayt* as 'temple' and *al-timthal* as 'carved image', while Ibn H̲anbal, in his restrictive view, read 'house' and 'image' respectively. Even if we consider that the ban was concerning mostly the depiction of animated being as Allâh, the Prophet, and all the creatures having a soul *(rûh̲)*, the semantics remains a source of dispute. To begin with, when the Mekkans built anew the Ka'ba after its destruction by fire, they painted the pillars

with images *(suwar)* of Prophets, Angels, and trees. Muhammad came then and ordered all the images to be erased, except those of the Virgin and Jesus (Wensinck, 1999: 927). Some put the emphasis on the erased images, other on the remaining ones. The ambivalence repeats in Medieval doctrines, the Persian Abû ʻAli al-Fârisî (901-979), linked to Muʻtazilite rationalism, and the Andalusian al-Qurtubî (d. 1273) took position in favour of images, while Mujâhid Ibn Jabr (d. 722) and al-Ghazâlî (1058-1111) pronounced themselves against images. We find here a first source of variation.

2. The prohibition of images is not based on Qur'ân directly, but on *hadith* literature. The Qur'ân is in fact almost mute on the point to know whether the images are forbidden or not (Besançon, 1994). The absence of qur'ânic injunction joined to the split of Islam into various movements explains the deep impact of exegesis onto the point. Islam is not a single stream: it experienced areas, branches, legal schools, sects, and factions. The different movements applied different precepts concerning representation. Among the main branches of Islam, Shiʻites tolerates images much more than Sunnites and Kharijites ever did. Among Sunni legal schools, Hanafite *madhhab* has been much more receptive than Mâlikite, Shâfiʻîte and Hanbalite. This is due to their respective position to personal reasoning *(raʻy)*, personal effort *(ijtihâd)*, and reasoning by analogy *(qiyâs)*. Hanafite school admit both and, as it recognizes a form of self-determination, it is considered as the most liberal school. Mâlikite also admits the three criteria, but aggregates scholars' consensus *(ijmâʻ)*, a manner of curbing individualism, while admitting any innovation satisfying general interest. Shâfiʻîte *madhhab* renounces to *raʻy* and *ijtihâd*, and it is thus responsible for the fossilization of *ijtihâd* devoid of its individual component; Hanbalite rite, opposed to Muʻtazilite rationalism, precludes both of three, it is thus the most rigorist school—the Wahhabite or Salafist movements proceed from.

3. The attitude regarding images varies according to the native cultures the Arabs conquered (the Roman, Byzantine, or Sassanid substrata, for instance). When the natives had a representational culture established for long, Islamic civilization took their features over. And this is why Empire peripheries were often less reluctant to representation than the centre. The combination of factors explains quite well the non-homogenous distribution of representations in space and time. The Umayyads, Nasrids, Fatimids, Ottomans, Ghaznavids, Saljûqids, Tîmûrids, Safawids, Qajars, and Mughals favoured depiction at a point defying what ever could imagine the Almohads, Almoravids, or Ayyubids. The aggregation of the previous factors brings to light a geographical contrast: Maghrib—apart al-ʻAndalûs—, East

Africa, and Arabian peninsula mostly receptive to abstraction, in particular to the geometrical patterns used for mural tessellations and roof woodcarving *vs*. Near and Middle East, Turkey and Central Asia basically iconophilic.

Any look on the semantic ambiguities, theological divisions, and ethnical substratum thus shows attitudes covering the entire spectrum from iconophily to the most rigorist aniconism. Many artworks can illustrate the presence of iconic representations in Islam.[12] There is also a testimony in Ibn al-Haytham's *Kitâb al-manâẕir*, Book II Chapter 3, and Book III Chapter 7, where he embarks on a detailed analysis of beauty (Sabra, 1989). Considering beauty *(ẖusn[13])* among visual qualities *(al-ma'ânî al-mubsara)*, he examines all the combinations of qualities that affect visual perception. His analysis is not restricted to the beauty of natural world. In several passages, he unambiguously speaks about the beauty of paintings and sculptures *(nuqûsh wa tazâyîn)*.

Being iconic paintings favoured in some areas, and beauty conferred to them, aniconism cannot explain the distinctive features of Islamic art as a whole. We must here partake the view that "the categories that have traditionally been used to describe Islamic art such as 'aniconic' and 'nonrepresentational' are unhelpful for the problem at hand" (Gocer, 1999: 685). But there is another argument to be pointed out. Had the images been forbidden, perspective pictures should have had all the chances to escape the interdict. Being a mode of depiction of carpentered worlds, as buildings and furniture, perspective is not directly concerned by the question of creatures. This point is for instance confirmed by the decoration of the Great Umayyad Mosque in Damascus (705-715). On the prayers hall façade, west portico, and treasure, several mosaics represent palaces and cities, decorated with branches, but without anybody inside. Rules of linear perspective could evidently apply to those representations, although they did not. Finally, the religious factor does not explain the iconic restriction in Islam, but only the non-homogenous distribution of representations in space and time.

The Axiological Factor: Overt Antirealism

The renewal of contemporary sociology greatly benefited from Boudon's contribution on the cognitive rationality and from the attention he paid to axiological motives, especially in the artistic domain (Boudon, 1995ab). He crossed the gap between conventionalism and Platonism, drawing his theory from 'axiological rationality' (Weber, 1956). This is an ideal framework for tackling the problem anew. What is indeed apparent in Islamic art, is the ambivalent attitude regarding *ḫadith*—and to follow or to get around a prescription is a sign of a value-based behaviour. To illustrate such ambivalence, we can evoke the opposition between the antirealistic features defining the major Islamic iconic artworks, and the competing theory of realistic illusionism developed in the optical literature.

As we said, in his *Kitâb al-manâẕir*, Ibn al-Haytham embarks on the question of illusionism in painting *(al-ṣuwar al-muṣawarra)*. In this account, he appears to be a good witness of painters' ambiguous attitude about representation:

> "Painters make their pictures and paintings *look like* the visible bodies to which they correspond, and by means of flat pictures they represent particular animals, individuals, plants, utensils or other solid objects, and their features. For this purpose they make skilful use of colours and drawings, paying particular attention to points of *resemblance*. For example, when they make pictures of hairy animals, fuzzy plants, rough-surfaced leaves or visibly coarse bodies, they make them *look like* the visible roughness of the surfaces of those animals or plants or inanimate bodies by means of drawings, outlines and different colours, though the pictures they make are flat and smooth or even polished. They also make pictures of individual people, *imitating* what is visible in their forms of the outlines of their faces and bodies, their hair, the pores and wrinkles in their skin… Painted pictures will be perceived *to be like* the forms they represent if those who made them were skilled in the art of painting." (Sabra, 1989, 1: 295, italics mine).

On the other hand, it is hard to find paintings conform to Ibn al-Haytham's statement. Any survey of iconic paintings would show, by contrast, that realism is always hampered and knowingly corrupted. The most accurate view onto the point is that "the artist can get around the prohibition if he exhibits that he does not want to imitate the reality" (Papadopoulo, 1976: 55). Islamic iconic art is thus ascribed to a specific aesthetical value: the "principle of unlikelihood". In frontal projection as "Prince and Attendants", from a *Dîvân* by Jâmî (**Plate 1A**), and in oblique projection as "Ulugh Beg with Ladies of his Harem" from a Timurid Book (**Plate 1C**), there is a propensity to erase relief, shadows, spatial coordination, and point of view[14]—a skilful tactic to get around the *ḫarâm*.

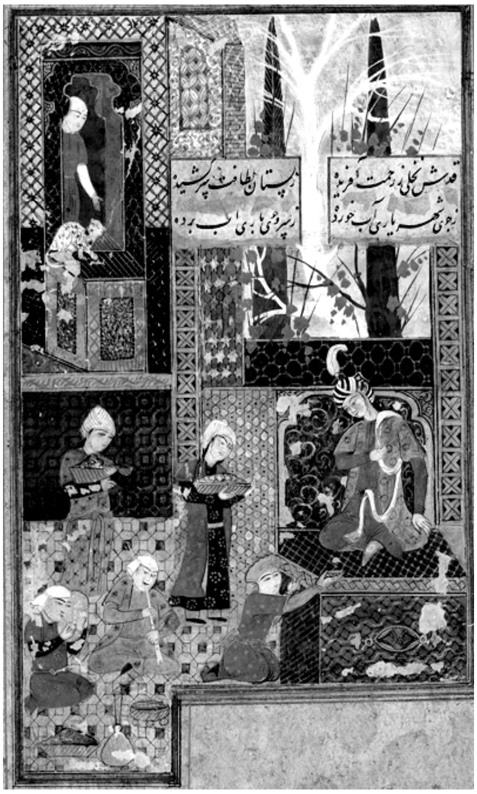
1. *Shadow* is only rarely cast on objects or individuals, except in some late Mughal miniatures of the XVIth century as the scene "The Loading of Gold" from the *Book of Babur* (New Delhi, National Museum, Visual Arts Gallery). This lack of shadowing could be a reference to *Saḫîḫ*'s commentary, where Nawawî generalizes the opinion of some ancient jurists, that "only reproductions that cast a shadow are forbidden" (Wensinck, 1999: 926). It is

a manner to strengthen the difference between painting and sculpture, claiming that lawful plane pictures are not to be confused with illicit three-dimensional idols.

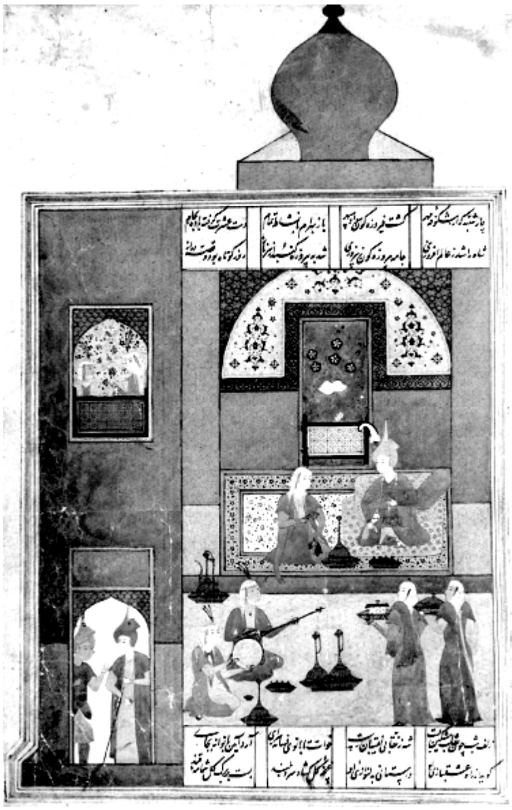
2. *Relief* is seldom treated in painting, except perhaps in some Ottoman miniatures as "The Nomad Camp" by Siyah Qalem (Istanbul, Topkapı Sarayı Müzesi). Insofar as relief, depth, drape, etc. imitate three-dimensionality *(al-tajassum)* of the depicted objects, they come under the previous case. The XI^th^ century's Monophysite Yahyâ b. Jarîr writes: "As to prevent the faithful take them as idols, the images were painted flat and non corporal" (Papadopoulo, 1976: 58). Here again, painters' tactic could have been to enforce the distinction between volumetric and flat images, in order to escape the iconic proscription.

3. *Point of view* is always missing. Despite their names, frontal and oblique *parallel* projections differ much from isometric *parallel* projection. In isometric projection, the parallels result from the fact the point of view is situated at infinity. By contrast, there is no point of view in frontal and oblique projections, because they are pure mathematical conventions: it is not possible to see at the same time the front side without deformation, and the lines emerging perpendicularly to it. There is various possible explanations to the parallel projection choice,[15] but it is not dubious that it fits—better than any other system—with antirealistic values.

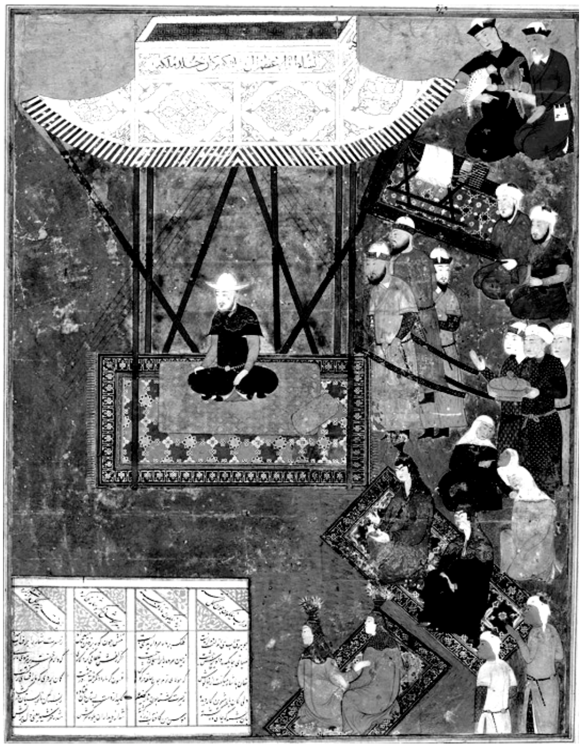
4. *Spatial coordination* of pictorial elements is usually lacking for, in the same scene, the painter could represent different objects according to various systems. Some rare exceptions happened in Central-Asian painting. We can cite the case of "Bahrâm Gûr in the Turquoise-Blue Pavilion", a scene from the *Khamsa* by Nizâmî (**Plate 1B**), and "The Feast of 'Îd" from a *Dîvân* by Hâfiz (**Plate 1D**). This feature can be understood as an implementation of 'atomism', taken either as a metaphysical outcome (Massignon, 1963, I: 12-13), or as a practical leaning that influenced Islamic civilization—the Bedouin nomadic form of life facilitating a sequential way of thinking.[16]



1A. Uncoordinated frontal projection



1B. Coordinated frontal projection



1C. Uncoordinated oblique projection

1D. Coordinated oblique projection

Plate 1.—1A "Prince and Attendants", *Dîvân* by Jâmî (Safawids) S 1986.49.—1B "Bahrâm Gûr in the Turquoise-Blue Pavilion", *Khamsa* by Nizâmî (Safawids) F 1908.275a.—1C "Ulugh Beg with Ladies of his Harem", in a book from Samarqand (Timurids) F 1946.26.—1D "The Feast of 'Îd" from a *Dîvân* by Hâfiz (Uzbeks) F 1932.51. Courtesy of Freer and Sackler Galleries, © Smithsonian Institution, Washington D.C.

Conclusion

We have thus to solve the puzzle in a way that differs much from the specific solution foreseen by Weber (1922), that is nonetheless in keeping with the concept of axiological rationality. The idea that linear perspective arose only in the West due to the strength of an unusual process of rationalization is denied by the fact that IXth century Islamic scholars had yet a thorough knowledge of the optical and geometrical materials required in perspective. In addition, the process of rationalization was rarely so intense as in that time, because truth uniqueness and scientific communalism were core values of Medieval Islam.[17] The perspective puzzle is not a matter of less or more rationality, but a matter of axiological motives. First, Islamic disregard for perspective is the result of a value-set insofar painters were fearing the *hadîths*' prohibition, or wished to avoid pretentiousness of their name *(musawwir)*. Second, Islamic art did not draw from Qur'ân and *hadîth*'s precepts directly. Third, painters implemented axiological motives, to put iconic practice in accordance with aniconic leanings. As a result, it is clear that such overt antirealism could be nothing but the main obstacle to the rise of linear perspective in Medieval Islam.

Finally, the question of Islamic disregard for practical perspective provides a shortcut towards the classic study of Renaissance perspective. I have argued elsewhere that Franciscan sensualism—realism—played a key role in the enhancement of perspective in trecento and quattrocento Italy (Raynaud, 1998: 291 *sq*). The multifaceted question of the rise of perspective cannot avoid an explanation by the aesthetic values: the call for realism makes clear the search for linear perspective in Late Medieval Italy, as overt antirealism elucidates the lackadaisical attitude of Islam regarding perspective.

Sources

Alberti, L.B. (1992) *De la peinture / De pictura (1435)*, ed. J.-L. Schefer, Paris: Macula.

Amir-Moéz A.R. (1963) "A Paper of Omar Khayyam", *Scripta Mathematica*, 26: 323-337.

Archimedes (1970) *De la sphère et du cylindre, La mesure du cercle, Sur les conoïdes et les sphéroïdes*, ed. Ch. Mugler, Paris: Les Belles Lettres.

Barbaro D. (1568) *La Practica della Perspectiva*, Venice: B. and R. Borgominieri.

Bîrûnî (1967) *Tahdîd nihâyât al-amâkin (The Determination of the Coordinates of Cities)*, ed. J. Ali, Beirut: AUB.

Cardano G. (1550) *De Subtilitate Libri XXI*, Nuremberg, J. Petreius.

Danti, E. (2003) *Les deux règles de la perspective pratique de Vignole, 1583*, ed. P. Dubourg-Glatigny, Paris: CNRS Éditions.

Francesca P. de (1984) *De Prospectiva pingendi*, ed. G. Nicco-Fasola, Firenze: Le Lettere.

Ibn Khaldûn (2002) *Le Livre des exemples,* 1. *Autobiographie, Muqqadima,* ed. A. Cheddadi, Paris: Gallimard.

Kheirandish E. (1999) *The Arabic Version of Euclid's Optics (Kitâb Uqlîdis fî ikhtilâf al-manâzir)*, New York: Springer.

Medovoi M.I. (1960) "Ob arifmeticheskom traktate Abu-l-Vafy", *Istoriko-matematicheskie issledovanija*, 13: 253-324.

Rashed R. (1997) *Oeuvres philosophiques et scientifiques d'al-Kindî*, vol. 1. *L'Optique et la Catoptrique*, Leiden: E.J. Brill.

Rashed R., Bellosta, H. (2000) *Ibrâhîm ibn Sinân. Logique et géométrie au Xe siècle*, Leiden: E.J. Brill.

Sabra A.I. (1989) *The Optics of Ibn al-Haytham: Books I-III On Direct Vision*, 2 vols., London: The Warburg Institute.

Saidan A.S. (1977) "Kitâb tastîh al-suwar wa-tabtîh al-kuwar", *Dirâsât*, 4: 7-22.

Saliba G. (1981) "Risâlat Ibrâhîm b. Sinân b. Thâbit b. Qurrâ fî al-ma‘ânî al-latî istakhrajahâ fî al-handasa wa al-nujûm", W. al-Qâdî, ed., *Studia Arabica et Islamica*, Beirut: AUB, 195-203.

Vinci, L. da (1970) *The Notebooks of Leonardo da Vinci*, ed. J.P. Richter, New York: Dover.

Yadegari M., Levey M. (1971) "Abu Kamil's on Pentagon and Decagon", *Japanese Studies in the History of Science*, Suppl. 2, Tokyo: History of Science Society of Japan.

Studies

Aghayani Chavoshi J. (1997) *L'Oeuvre scientifique d'Abû al-Wafâ' al-Buzjâni*, vol. 1. *Etude sur l'oeuvre géométrique d'Abû al-Wafâ'*, vol. 2. *La géométrie pratique d'Abû al-Wafâ'*, doctoral thesis, Paris: Université Paris 7.

Allen T. (1988) *Aniconism and Figural Representation in Islamic Art. Five Essays on Islamic Art*, Occidental: Solipsist, 1988.

Barrucand M. (1995) "Les fonctions de l'image dans la société islamique du Moyen-Âge", Beaugé G., Clément J.-F. eds., *L'Image dans le monde arabe*, Paris: CNRS Éditions, 59-67.

Besançon A. (1994) *L'Image interdite. Une histoire intellectuelle de l'iconoclasme*, Paris: Gallimard.

Blair S.S., Bloom J.M. (1994) *The Art and Architecture of Islam, 1250-1800*. New Haven/London: Yale University Press.

Boudon R. (1995a) *Le Juste et le Vrai. Études sur l'objectivité des valeurs et de la connaissance*, Paris: Fayard.

Boudon R. (1995b) "De l'objectivité des valeurs artistiques ou les valeurs artistiques entre le platonisme et le conventionnalisme", *Archives de Philosophie du Droit*, 40: 76-95.

Callataÿ G. de (2001) "Aniconisme et illustrations scientifiques en Islam", *Images, sciences et techniques*, Séminaire du Centre interfacultaire d'histoire des sciences, Louvain-la-Neuve: UCL.

Critchlow K. (1976) *Islamic Patterns: An Analytical and Cosmological Approach*, New York: Schoken Books.

Dold-Samplonius Y. (1993) "The Volume of Domes in Arabic Mathematics", *Vestigia Mathematica, Studies in Medieval and Early Modern Mathematics in Honour of H.L.L. Busard*, ed. M. Folkerts and J.P. Hogendijk, Amsterdam: GA, 93-106.

Dold-Samplonius Y. (1996) "How al-Kâshî Measures the Muqarnas: A Second Look", *Mathematische Probleme im Mittelalter. Der lateinische und arabische Sprachbereich*, herausgegeben von M. Folkerts, Wiesbaden: Harrassowitz Verlag, 57-89.

Ettinghauser R. (1962) *La Peinture arabe*. Genève: Skira.

Ettinghausen R., Grabar O. (1994) *The Art and Architecture of Islam, 650-1250*, New Haven/London: Yale University Press.

Gonzalez V. (1995) "Réflexions esthétiques sur l'approche de l'image dans l'art islamique", Beaugé G., Clément J.-F. eds., *L'Image dans le monde arabe*, Paris: CNRS Éditions, 69-78.

Grabar O. (1973) *The Formation of Islamic Art*, New Haven: Yale University Press.

Gutmann J. (1961) "The Second Commandment and the Image in Judaism", *Hebrew Union College Annual*, 32: 161-174.

Hagen M.A. (1986) *Varieties of Realism. Geometries of Representational Art*, New York: Cambridge University Press.

Klagsbald V. (1997) *A l'ombre de Dieu. Dix essais sur la symbolique dans l'art juif*, Louvain: Peeters.

Massignon L. (1963) *Opera Minora*, I, II, III, Beyrouth: Dar al-Maaref.

Özdural A. (1995) "Omar Khayyam, Mathematicians, and 'Conversazioni' with Artisans", *The Journal of the Society of Architectural Historians*, 54 (1): 54-71.

Özdural A. (2000) "Mathematics and Arts: Connexions between Theory and Practice in the Medieval Islamic World", *Historia Mathematica*, 27: 171-201.

Papadopoulo A. (1976). *L'Islam et l'Art musulman*, Paris: L. Mazenod.

Rashed R. (2003) "The End Matters", *Islam and Science*, 1: 2-7.

Raynaud (1998) *L'Hypothèse d'Oxford. Essai sur les origines de la perspective*, Paris: PUF.

Saliba G. (1999) "Artisans and Mathematicians in Medieval Islam", *Journal of the American Oriental Society*, 119 (4): 637-645.

Soucek P.P. (1999) "Taswîr", *Encyclopédie de l'Islam*, vol. 10, Leiden: E.J. Brill, 387-390.

Weber M. (1922) *Gesammelte Aufsätze zur Religionssoziologie*, Band I, Tübingen: Mohr.

Weber M. (1956) *Wirtschaft und Gesellschaft*, Tübingen: Mohr.

Wensinck J. (1999) "Sûra", *Encyclopédie de l'Islam*, vol. 9, Leiden: E.J. Brill, 925-928.

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[1] *Kitâb Uqlîdis fî ikhtilâf al-manâzir*, Prop. 42 (Kheirandish 1999: 146-147).

[2] *Kitâb fî taqwîm al-kha ta' wa al-mushkilât allatî li-Uqlîdis fî kitâbihi al-mawsûm bi-al-manâ zir*, Prop. 38 (Rashed, 1997: 272-275).

[3] *Kitâb Uqlîdis fî ikhtilâf al-manâzir* , Prop. 11 (Kheirandish, 1999: 34-37). I have changed the lettering according to al-Kindî commentary, for the sake of comparison.

[4] *Kitâb fî taqwîm al-khata'*, Prop. 11 (Rashed, 1997: 190-195).

[5] *Kitâb fî taqwîm al-kha ta'*, Prop. 6 (Rashed, 1997: 178-181). I have introduced little changes in the lettering in order to compare this proposition to the next one, by Qustâ b. Lûqâ.

[6] *Kitâb fî 'ilal mâ ya'ridu fî al-marâyâ min ikhtilâf al-manâzir*, Prop. 4-5 (Rashed, 1997: 582-585).

[7] *Liber Jacob Alkindi de causis diversitatum aspectus et dandis demonstrationibus geometricis super eas* , Prop. <6> (Rashed, 1997: 448-450). The last sentence comes in fact in the intercourse of the passage.

[8] *Kitâb al-manâzir*, I, 3 [2, 4] (Sabra, 1989, 1: 13, 14).

[9] "I liked his craftsmanship *(sun'atahu)* and found him to be technically clever *(latîf al-hîla)* in his work. So I dictated to him the description of the instrument, demonstrating how to set up on a spherical surface a gnomon whose shadow falls on the spherical surface during the whole day for all days of the years. I made my description for him of the type that befits those who work with their hands *(al-sunnâ' al-ladhîna ya'malûn bî al-yad)*" (Saliba, 1999: 641-642).

[10] "Some of the artisans favour the use of arithmetic and prefer it over craft *methods (yu'thiruhu 'alâ al-turuq al-sinâ'iya)*, as we have found with all the makers of astrolabes and instruments" (Saliba, 1999: 642).

[11] The thesis of a Jewish origin of this aversion is unclear. On the one hand, the aniconism expressed in the second commandment, *Exod* 20:4-6, as in *Exod* 32:1-4, *Lev* 26:1, *Deut* 4:15-18, *Deut* 5:8-9, *Deut* 27:15, and many Talmudic commentaries, is counterbalanced by *Exod* 25:18-20, *Num* 21:8-9, *Ezech* 1:26-28, *II Chron* 3:10-13, *II Chron* 4:3-4. On the other hand, Jewish art has always been submitted to iconic-aniconic similar tensions. See for instance the iconic paintings at the synagogue of Doura Europos (244-245) *vs*. the aniconic decoration of Samuel Halevi Abulafia's synagogue in Toledo (1357); the iconic miniatures by Isaac Sofer b. Obadia for Jacob b. Asher's *Arba a Turim* (1435) *vs*. the aniconic carpet-page micrographies of the *Bible of Burgos* by Menahem b. Abraham b. Malik (1260), etc. (Gutmann, 1961; Klagsbald, 1997).

[12] We can cite: the fountains of Madînat al-Zahrâ's palace near Córdoba (Spanish Umayyads); the fountain of Lions of the Alhambra in Granada (Nasrids); coins with the head of caliph 'Abd al-Malîk (685-705) (Umayyads); a lion hunting gazelles under a pomegranate tree, Khirbat al-Mafjar winter palace, Jericho valley, 724-743 (Umayyads); scenes of building, fishing, bathing, music playing and dancing, including naked girls, on the walls of Qsar 'Amra palace, Jordan, VIII[th] century (Umayyads); dancers on mural paintings in Dâr al-Khalîfa at Sâmarrâ', Iraq, IX[th] century ('Abbâssids); a *'ud* player on a carved panel of ivory, Egypt, XI-XII[th] century (Fatimids); fortresses and branches on the walls of the mausoleum of Baibars the I[st], Damas, 1277 (Mamluks); a rabbit on a dish from Tell Minis, Syria, XII[th] century (Saljûqids); countless lion incense-burners, Khorasan, XIIth century (Ghaznavids); a princely assembly painted on the walls of Lashkar-i Bâzâr, Afghanistan, IX[th] century (Ghaznavids); the many miniatures of *Shâh nâma* by Fîrdawsî (Ghaznavids), *Kalîla wa Dimna* by Ibn al-Muqaffa' (Tîmûrids), *Zâfar nâma* by Sharaf al-Dîn Yazdî (Tîmûrids), and especially the copy of Nizâmî's *Khamsa* for Amîr 'Alî Farsî Barlas, that even depicts the face of the Prophet in his *mi'râj*, prob. Herat, 1494-95 (Tîmurîds); two fighters in a page of Sâ'di's Gulistân, Bukhara, XVI[th] (Shaybanids); the animals that decorate the façade of Shîr Dâr *madrasa* in Samarqand, 1619-1635 (Janids); the widespread practice of *muraqqa'*, i.e. bound collections of calligraphies and paintings, under various dynasties (Safawids, Ottomans, Mughals)… (Ettinghausen and Grabar 1994; Blair and Bloom 1994; Barrucand, 1995; Gonzalez, 1995).

[13] The root *hasana* includes moral connotations that *jamala* has not.

[14] "From the aesthetic point of view, the plastic processes that provide those images tend to dematerialize them, and give them an ornamental nature rather than a descriptive one… Figures and animals come into existence and

are defined by outline and contours, not by relief and volume… Line dominance meets with a linear, non spatial, organization of the composition" (Gonzalez in Beaugé and Clément, 1995: 72-73).

[15] To begin with invariants related to each type of geometrical transformation. Eight basic invariants are known: distance (size, length), shape, area, angle size (perpendicularity), parallelism, collinearity (betweeness, straightness), ratio of division, cross-ratio (harmonic division). There are : 2 for projective transformation (cross-ratio, collinearity), 4 for affine projection (+ ratio of division, parallelism), 6 for similarity projection (+ angle size, shape), and 8 for metric projection (+ distance, area) (Hagen, 1989: 105). Suppose now—alongside Hagen's purposes—these properties actuate as a basis for the practical operations involved in the construction of each mode of depiction, thus projective transformation, i.e. linear perspective, suffers a severe disadvantage against other types.

[16] Ibn Khaldûn (2002) pioneered the study of opposite forms of life of Bedouin civilization *(al-'umrân al-badawî)* and sedentary civilization *(al-'umrân al-hadharî)*, but deals with painting only rarely. The Bedouins influenced notably scientific practical procedures. For instance, while Greek astronomers divided the sky into constellations, Arabic astronomers individuated the stars by a proper name *(al-dabarân* 'the Follower [of the Pleiades]' for α Tauri; *al-khibâ'* 'the Tent' for α Corvi; *al-mufrid* 'the Solitary One' for η Bootis, etc.) This is logical according to Bedouins (or Sailors) fundamental leanings. If one has to orientate himself in an open space as the desert (or the sea), he must develop an individual knowledge of the stars in order to fix a precise azimuth; hence the supremacy of stars upon constellations, a dominance that ties up partly with the cognitive distinction between 'conceptual' cartographic representations, and 'practical' sequential representations. Such routines could have applied to space perception in general, considering the parts as more relevant than the whole. It is exactly the case of Islamic painting, that grants autonomy to objects within the pictorial composition.

[17] "Islam provides a whole set of fundamental values. Among those values, one finds the uniqueness of truth, the lack of contradiction between revelation and reason, and thus between the two types of knowledge that they produce, the equality of human beings in jure before the truth and in the search for it, the pursuit of knowledge as a means to strengthen one's faith and as a form of prayer, the obligation to communicate knowledge and not to keep it to oneself, etc. These values, among others, have without the least doubt pushed forth research and have fostered creation of open scientific communities." (Rashed, 2003: 1).