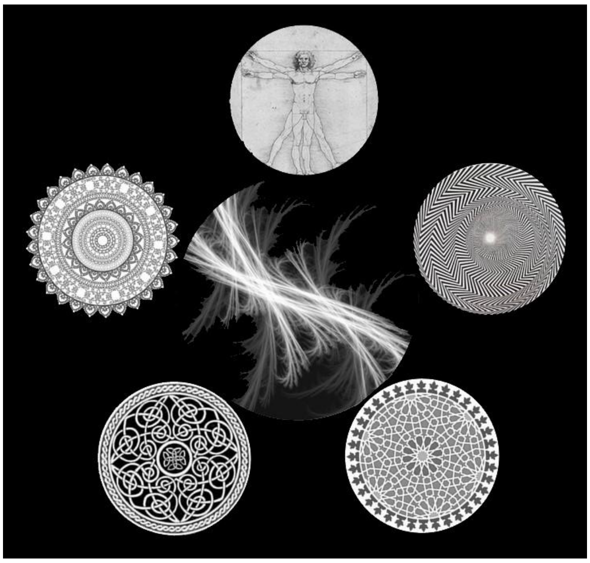
Geometry in Art and Ornament

by

Kevin Byron



This is a more detailed account of the presentation 'Geometry in Art and Ornament' by Kevin Byron which also includes weblinks to the four short videos shown in the talk.

A comprehensive account of geometry in art and ornament would be impossible in a single presentation, and what follows is a personal, rather than in-depth, scholarly study on some aspects of the subject. The aim was to begin to find answers to questions on the meaning and purpose of geometry in art and ornament from ancient times to the present day. Clearly there is no single answer to this, but rather than being faced with an encyclopaedia of facts with no overall story, I chose to find my own way through the vast territory of the subject with just a few short-cuts between important milestones in the highly entangled history of geometry in art.

I have to admit to a bias in identifying these milestones that could be summarised as a dissatisfaction with developments in art and ornament that have been interpreted purely from the perspective of the dramatic and bloody history of humans. That is to say the cyclic rise and fall of empires, kingdoms, cultures and religions. Of course the drama is there from the onset as what appears to be the dominant force for change. There is however, a perennial poetry and song in geometry that can be set apart from the drama, that is always there to be seen and appreciated in another way.

This relates not only to the largely anonymous artistic creativity that shines through the entire history of art and ornament, but to a desire by the artists themselves to work with terrestrial materials to design shapes and form that are of themselves not of this Earth. By its very nature, experience of this other dimension to geometry is compromised by too much description. However, holding the idea in my mind, guided a route through the vast expanse of art and ornament, and it is hoped that some of its essence was retained for the reader of the presentation.

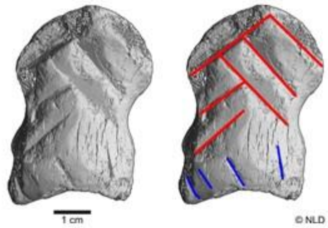
In order to set this context for the overall presentation, the notes following the introductory slide are quite lengthy compared with the remaining slides. Note: For simplicity most of the presentation only discusses 2-dimensional ornament and art. The main discussion points are given below:

- Introduction
- The Origins of Geometry
- Interlace and Knot-work
- Islamic Geometrical Design
- Higher Order Geometry
- '…isms' and The Present Day

Introduction

Symbolic expression:
Shells, 500,000 Ya - Indonesia

51,000 Ya – Germany



Earliest cave art?
64,000 Ya – Spain

"The greatest innovation in the history of humankind was neither the stone tool nor the steel sword, but the invention of symbolic expression by the first artists." *C.Walter*

Two positions on the meaning of early art:

1. "The creation of images from the imagination, or 'the mind's eye', required a seminal evolutionary change in the neural structures underpinning perception; this change would have had a survival advantage in both tool-making and hunting."
Gillian M. Morriss-Kay
…..maintains conventions, beliefs and identities that characterise human societies.

2. It marked the evolution of self-awareness, the notion of individual separation from nature and from others. Art enables us to 'spiritually' re-connect.

Two generalised positions on the origin and purpose of art and ornament are given in the slide above and the first is the now all-pervasive, scientific world view. It is essentially reductionist and based on the belief that everything can be explained rationally and stitched together from the available facts. The assumed reference points are evidence-based scientific and socio-psychological theories of material and cultural evolution. In terms of the enduring debates on the nature of being human and given the current thinking in debates on religious belief, this is an atheist position. That is to say it does not (and indeed could not) depend on validation from ideas on other non-evidence-based (ie arational – as distinct from irrational) dimensions to life, the inner teachings of religious movements or the supernatural.

The second position offers a wider perspective on being human than that offered by scientific explanations, and draws on our innate belief in (for want of a better word) the supernatural (in the sense of 'spiritual' rather than phenomena-based associations with the term such as telepathy etc). For example, even the most hard-nosed rationalist is not likely to inform their loved one that the reason they feel that way is due to a mutual imbalance of the neuro-peptide oxytocin in their hypothalamus. Instead they hold another non-physical view which can't be simplified through reason, but can be expressed in poetry, symbols and music for example. These latter forms are indirect ways of communicating feelings and experiences that are not linear, reasoned arguments.

Science is a human invention (ie a product of the mind) that - in spite of many centuries of philosophical thought, and scientific investigation - has no clue as to the origins or nature of the state of being conscious in humans. Indeed it could be described as a mystery that hides in plain sight, greeting us each day with an array of sensual experience, thoughts and feelings as we awaken.

All that is reasonably well known is that about 3.7 billion years of material evolution of life on Earth led to a species that gradually acquired an acute awareness of its own existence, and with that - its mortality. On the face of it this characteristic offered no evolutionary survival value, as much simpler creatures lacking such an extraordinarily developed faculty have survived in greater numbers, for a much longer time than humans. Indeed, it could also be argued that cultural evolution and civilization - which is a direct result of a creature possessing a fully conscious mind (ie humans) - has evolved to the point whereby the future of the species is at threat of exctinction from to its own behaviour.

Conscious awareness, which - because of its familiarity - is taken for granted, can be equated with a sense of individuality and a consequent feeling of separation from other fellow humans and from the natural environment. This state of separation and knowing one exists motivates a desire to re-unite through some form of communication. There are other survival-based reasons for communicating of course concerned with the 1st position discussed earlier.

Early forms of communication included gesticulation and audible utterances that eventually led to speech and oral language. The creation of symbols on surfaces was next leading to written languages. However, another class of symbolic expression appeared much earlier during the late paleolithic period, and this is what is generally referred to as art.

One could easily draw on the scientific world view when examing for example cave art, and suggest that the reason for drawing animals would be to signal to others that this area is a good hunting ground (ie it had survival value). However the earliest art forms were not figurative and more closely resembled geometric shapes such as lines and circles. They were scribed on stone surfaces and animal bone and had no obvious function, yet they appear in many places around the world. These symbols are a form of ornamentation, that demonstrate an ability to think abstractly and to imagine. This ability to think about concepts that are not tied to concrete experiences, objects, people, or situations, appears to be a direct consequence of the emergence of conscious awareness.

Abstraction itself is an expression of separation between what exists in real terms in the outside world and what has no real existence except in the mind. There is a sense of reunion however when an abstract idea is communicated and perceived by others. Love is an example of this.

Early humans lived on the edge of survival in hostile and unpredictable conditions for which they had little if any knowledge, let alone control. It follows therefore that with this newly acquired faculty of being able to imagine things that had no physical presence, they began to develop ideas about unseen forces that determined their fate. In other words living in the midsts of chaos, they invented another world that was ordered and had control over their lives. The early geometrical marks of straight and parallel lines and circles then may have been early symbols for this other world where there was order and perfection.

The imagination is a blank sheet of paper on to which anything can be scribed, and over time the prehistoric tribal elders and shamans developed their own formulations for this other world which involved orally transmitted stories, rituals and ornamental art. They would also have been regarded by their tribe as having some form of contact with this other world. Furthermore it is not unreasonable to assume that faced with the awareness of mortality, that a belief developed that after death the individual crossed over into that invisible world, because their life could no longer been seen in the real one.

In effect this was the beginning of religion, though it's worth a reminder about the etymology of the word. Some experts suggest that the word 'religio' may have derived from the verb 'religare,' meaning 'to bind' or 'to connect.' Rather than the relatively recent idea of religion based upon a belief system and a having a faith in an omniscient, omnipotent being, this earlier form was more connected to the idea of separation from an earlier state, and a desire to be permanently re-united with it. Many tens of thousands of years later the Genesis myth captured these ideas very clearly. There was the acquistion of knowledge (ie awakening of consciousness) and the consequent casting out of Eden and a desire to return to the state of unity again.

There is also the notion of a state of perfection in geometric symbols given that all organic life only ever approximates to pure straight lines or perfectly formed circles. Coupled with the apperance of rituals associated with birth and death in those times, it is reasonable to extrapolate to a belief that re-connection was something that also happened after death.

Geometric symbols then represented another, imagined world in which there was order and perfection, and in common with stories they provided a sense of meaning and security in an unpredictable, chaotic world. This was clearly articulated by Karen Armstrong when she wrote:

"Human beings fall easily into despair, and from the very beginning we invented stories that enabled us to place our lives in a larger setting, that revealed an underlying pattern, and gave us a sense that, against all the depressing and chaotic evidence to the contrary, life had meaning and value."

Karen Armstrong (Author of 'The Great Transformation')

It’s clear that a question arises with regard to the notion of ‘imagined’ or ‘invented’ geometric art and stories that point to another dimension to life - and this concerns their validity. By definition there is no evidence of this in the material world other than the secondary constructions or simulations created by humans. But maybe the aforementioned idea of separation associated with the appearance of conscious awareness is sufficient! A sensitivity to this is felt by most people, irrespective of any belief system, and it may be the reason that we hear so often, words put simply to the effect: “There must be more to life than this…!” Some people are driven to seek this ‘more’ and there has been different cultural formulations over history for guidance with what is generally referred to as ‘Seeking Truth’. This work is qualitatively different to subscribing to an organised religion in the conventional meaning of the term.

Further examples of historic geometric design

Mammoth Ivory, Siberia (10,000 BC)

New Grange, Ireland (3,000 BC)

Achnabreck, Scotland (10,000 BC)

Val Camonica, Italy (1,000 BC)

Peru (100 AD)

The straight line and the circle are fundamental geometric constructions and both have real and other-worldy meanings. On the one hand they represent boundaries that can define ownership and protection and on the other they represent eternity. The two main geometric art forms discussed later – Celtic knotwork and Islamic Design depend entirely on the line and the circle, with the former in terms of construction, placing more emphasis on the line initially and the latter on the circle.

James Trilling in his book ‘The Language of Ornament’ defines ornament and identifies a modern problem with regard to its appreciation:

“ the elaboration of functionally complete objects for the sake of visual pleasure - has a unique place among the arts. It is as old as humankind, yet for most of the twentieth century, it was systematically excluded from the mainstream of Western art-making and art appreciation…………”

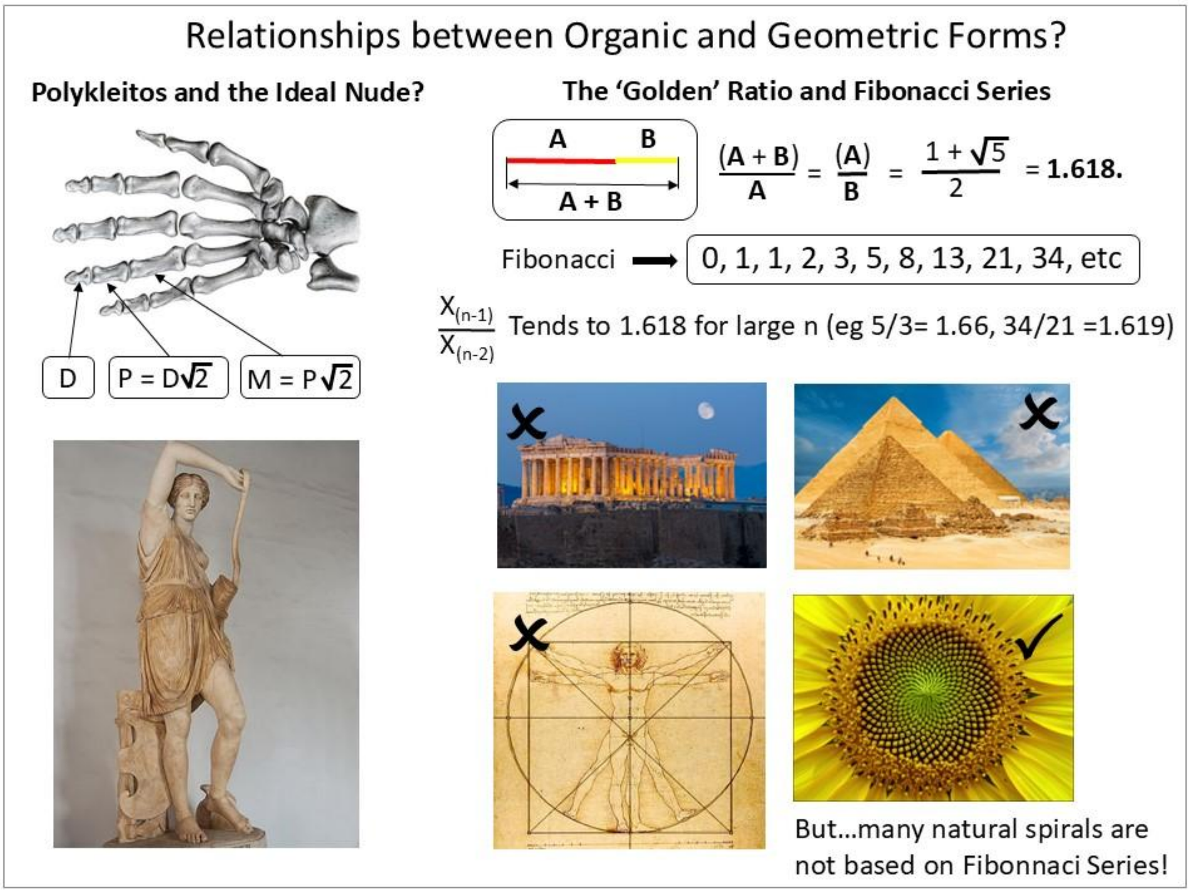
As discussed in the final section ‘…isms and the present day’, in the early 20th century with the full emergence of abstract art, geometry also made an appearance as art rather than ornament. Amidst numerous art movements, many artists transitioned their work from figurative to abstract art and in some cases, ultimately to simple geometrical shapes. This has been interpreted as a yearning to recover the original primeval significance of geometry (see later).

The first civilisations developed about 6000 years ago (ya), and both geometric and organic ornamententation were often seen alongside each other. In some cases, such as the Egyptian vase they are ambiguously combined, so the wavy lines could be geometric curves or an organic design (ie resembling sea-waves). The Ishtar Gate was the eighth gate to the inner city and is adorned with a variety of animal designs (dragons, bulls and lions) symbolising the gods Marduk, Adad and Ishtar.

Writing was developed independently in Mesopotamia (5,400 ya), Egypt (5,300 ya) and China (3,200 ya) and the first Latin alphabet dates back to around 2,700 ya. Roman Square Capitals which are geometrically precise, emerged about 1900 ya in Rome, and an example is shown below.

An insciption on a triumphal column dedicated to the Roam emperor Trajan.

Given the innate creativity of humans, it is inevitable that writing would eventually be viewed as an art form, leading both to calligraphy and illuminated writing through combining writing with other forms of ornamentation.



We take a huge jump forward now from the late Paleolithic period ~50,000 ya, to the time of early Classical Greece around 2,500 ya and about a hundred years after mathematics had begun to be formalised. This was a milestone in that relationships were now being developed between organic and geometric forms.

The earlier Ancient Greeks believed that everything in nature was under the control of the gods (the hidden forces of the people of the late Paleolithic era), as indeed were the relationships between humans and nature, from which we had become separated. Combine the 'other worldy' nature of geometry discussed earlier, with the Hippocratic principle of isonomia (equlibrium), and other aesthetic considerations of the time such as symmetry, balance and elegance, and it became clear that there must be relationships between humans and geometry. This idea was developed by Polykleitos who was a sculptor living at that time, who developed a new approach to sculpture. He wrote a treatise describing his theory of the mathematical basis of ideal proportions exemplified by a sculpture of an ideal male nude. He is quoted as saying: *"Perfection ... comes about little by little (through many numbers)."* By this he meant that a statue should be composed of clearly definable parts, all related to one another through a system of ideal mathematical proportions and balance. As shown in the figure above, an example of some of these proportions are quantified for the phallanges in the hand. Of course no humans would have such ideal proportions, though the notion persists today in a rather tawdry way.

We jump forward another 200 years to the time of Euclid (see later), who wrote about an unusual entity that became known as the golden ratio or the divine proportion that made a frequent appearance in geometry. In his 'Elements' Euclid defined it the following way:

"A straight line is said to have been cut in extreme and mean ratio when, as the whole line is to the greater segment, so is the greater to the lesser."

Even though this ratio has visually pleasing qualities, when other ratios are used that determine the size say of a picture frame, studies have shown that we are unable to identify the golden ratio very accurately. Most artists select their frame size based on the art-work however, and the golden ratio isn't widely used (though Lee Corbusier and Salvador Dali did explicity proportion their work to approximate to it presumably to add an element of mystery).

In 1876 Gustav Fechner was the first to investigate the role the golden ratio plays in human perception of beauty, and other studies have been conducted since but remain inconclusive. This ratio does appear in various patterns in nature, but then so do other ratios that have not been endowed with special significance. Several myths are in circulation about the golden ratio in architecture and art, but actual measurements have shown it to be absent, and this includes The Parthenon, The Egyptian Pyramids and Leonardo's Vitruvian Man.

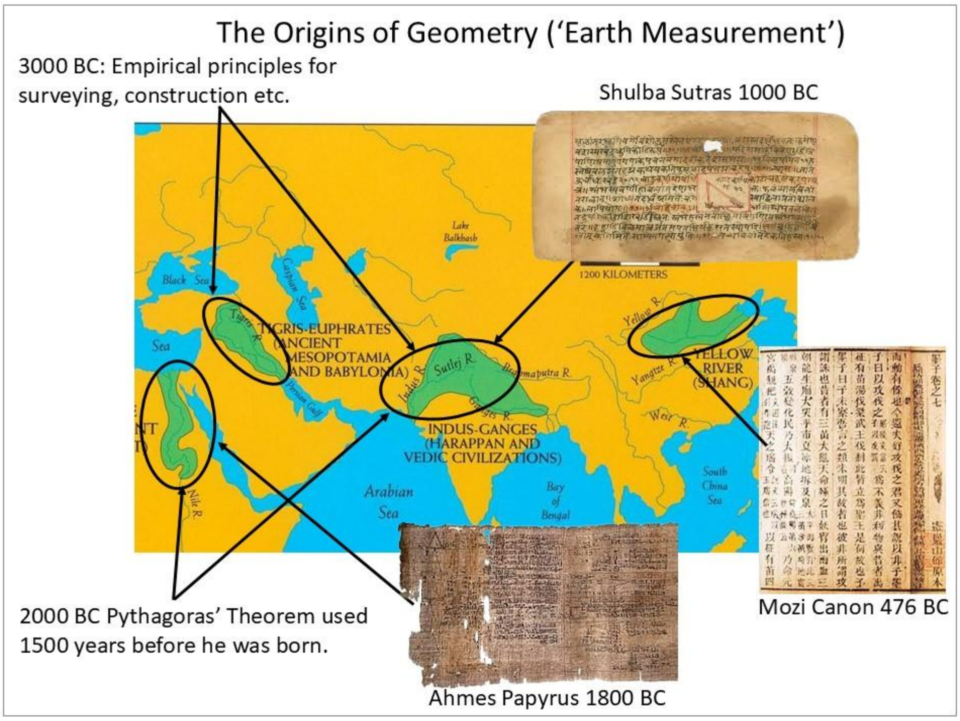
It's worth mentioning the Fibonnacci series here because it also connects geometry with mathematics. This series was first described in Indian mathematics as early as 200 BC in work by the poet and mathematician Pingala. This was in connection with patterns of Sanskrit poetry formed from syllables of two lengths. The Italian mathematicin Fibonnacci brought the series to the West in 1202 when he published a book called the Liber Abaci. This publication also demonstrated the superiority (eg the use of a decimal point) of the Hindu-Arabic arithmetic system over the Roman numeral one, and this eventually led to the former system being adopted in the West.

The Fibonnaci series turns up in many areas of science and mathematics and is applied widely today. In biological settings it appears in the branching of trees, the arrangement of a pine cone's bracts, artichoke flowers and leaves on a stem etc. The ratio of consecutive terms in the Fibonnaci series tends to the Golden Ratio and is accurate to three decimal places after the 9th term.

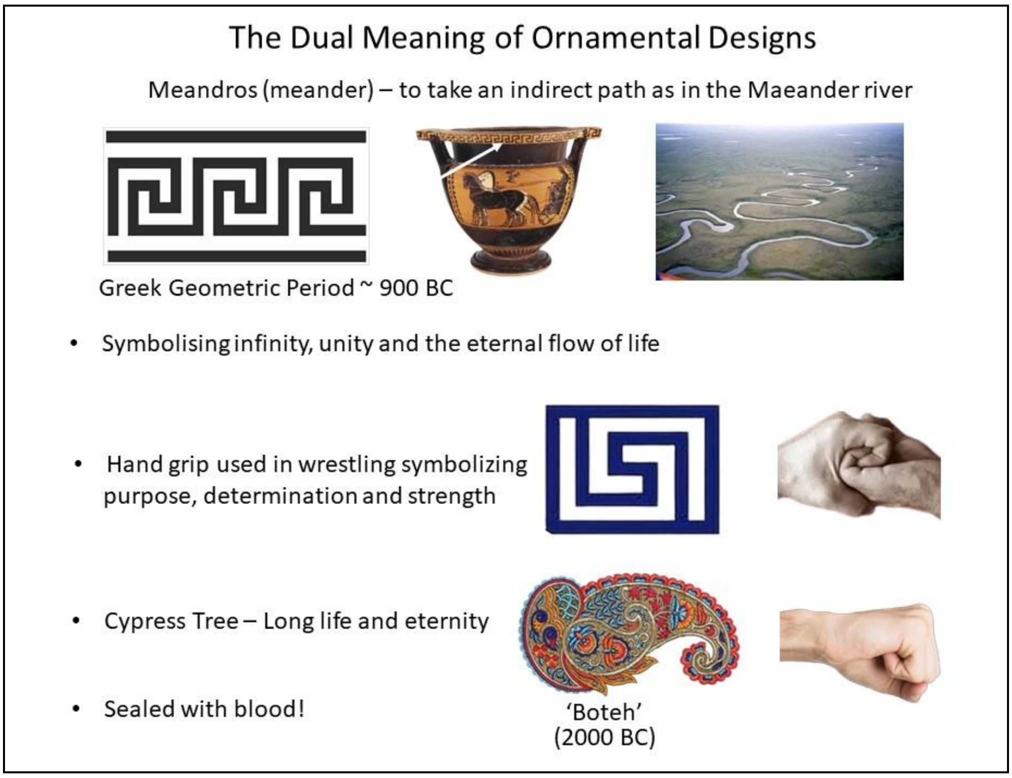
As a footnote, it's worth remembering that some numbers are intrinsically geometric for example the square of a number can be drawn as a real square (eg 4 represents a 2 by 2 square, 81 is a 9 by 9 square and so on). Similarly a triangular number can be represented by an equilateral triangle so 3 is a triangular number as is 6, 10, etc.

To conclude this section, the Golden Ratio has been widely cited as a mystical number, in that it appears to bridge the abstract world of geometry and mathematics with nature. Many examples of its appearance in architecture etc, however, have been shown to be wishful thinking rather than factual truth.

It's interesting to enquire on the motivation for this wishful thinking, and it appears to be driven by a desire to find and experience harmony in ordinary things, to bring us into a closer presence with the hidden world and nature from which we have been separated. Whilst it can be an energising experience, it is essentially an emotional one. It can also stimulate a desire to continue looking for similar patterns, which is tantamount to reading pages of wise quotations in the belief it will endow us with wisdom. The effort is mis-directed and requires a re-orientation. Finally, although the presentation is tilted more towards exploring the 2nd of the two positions on the meaning of geometry described in the second slide, it's important not to ignore the findings of the 1st position. That is to say, the non-scientific beliefs we hold (position 2) which give a greater meaning to our lives, should however continue to be challenged by science (but never wholly rejected), because they invite us to be flexible and to re-think, refine, explore and develop them within ourselves. This appears to be an essential requirement for seeking Truth. As one modern commentator stated: *'When you are most certain, that is the time to have most doubt!'*



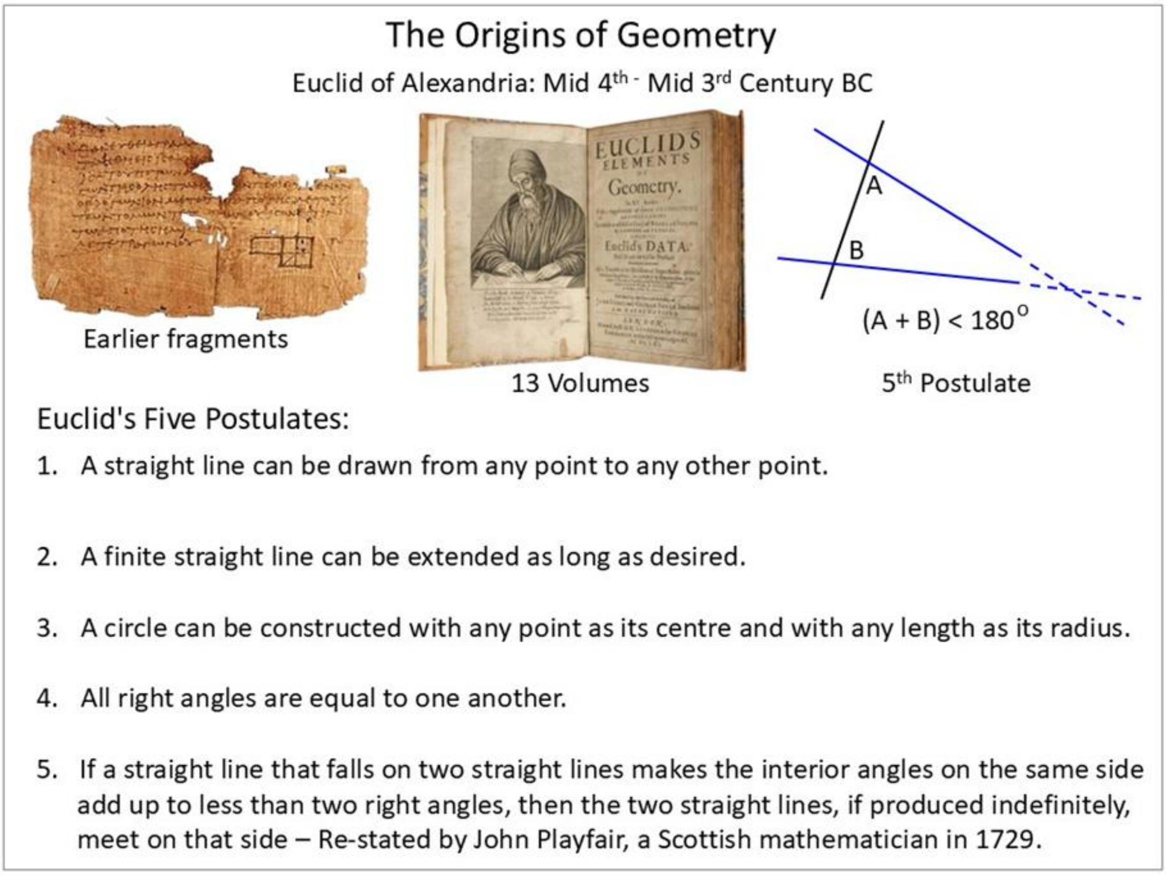
Before discussing Euclid, it's worth noting that many hundreds of years before he published 'The Elements' a great deal of emprical geometrical and mathematical knowledge - notably Pythagoras' Theorem - had already been acquired in the four early civilisations, as summarised in the slide above.



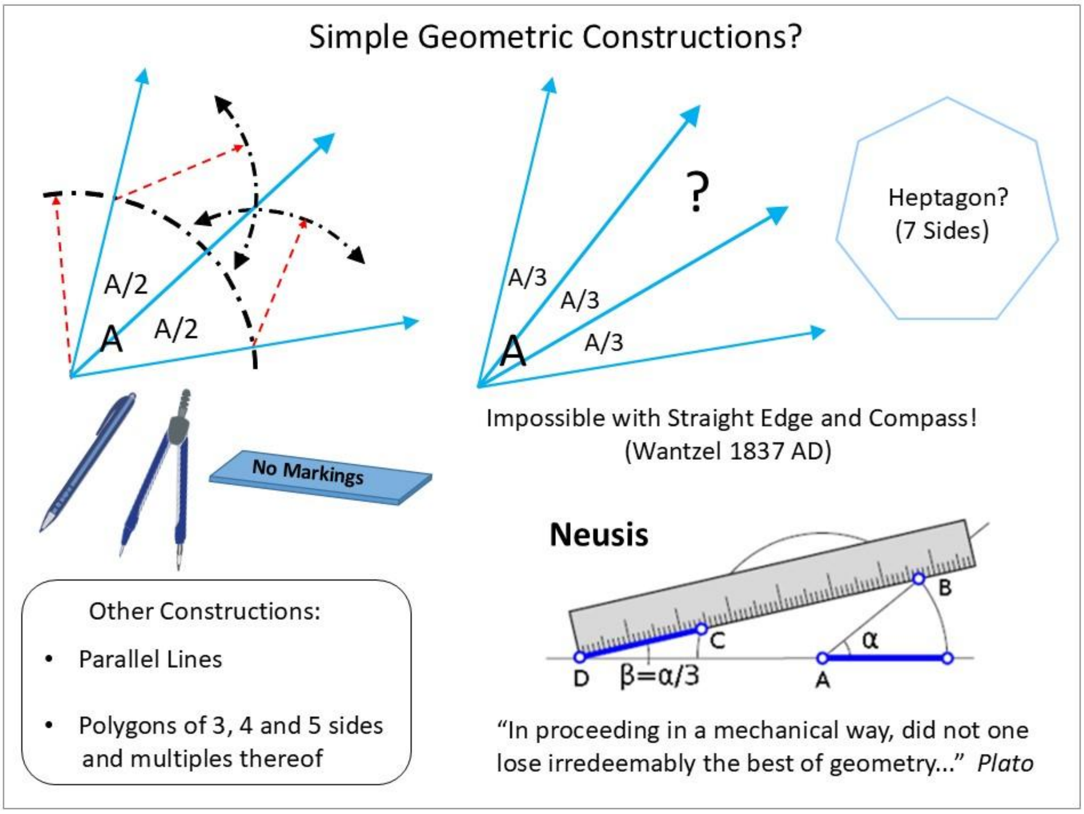
A very popular geometric design that can be found in many cultures is popularly know as the Grecian Key or Meandros and examples are given above. The purpose of this slide however is to reiterate that symbols can have different, sometimes opposing interpretations, and in this case they fall into the two positions on the meaning of art and geometry discussed in the introduction. On the one hand the Meandros represents a spiritual connection to life, and on the other it is grounded in survival.

Similarly with the organic Paisley design that originated in Persia (known as the boteh or buta) over 5000 years ago resembling a teardrop. It is thought to have been a representation of a floral spray combined with a cypress tree, which is a Zoroastrian symbol of life and eternity. However another interpretation suggested that when pacts were made between enemy tribes, the bottom of the leader's clenched fist was smeared with the other leader's blood and pressed on to a surface leaving an impression of the boteh shape, meaning that the pact was bonded with blood.

The default interpretation of symbols is often aligned with the scientific world view because - in contrast with the 'spiritual' perspective - it offers certainty and resolution and the mind, like nature, abhors a vacuum. However, exploring other interpretations can stimulate a state of liminality in which one can reflect and refine one's own beliefs. Making progress in seeking answers to 'spiritual' questions requires a certain degree of creative thinking and unlearning of earlier beliefs, and a greater tolerance to ambiguity.



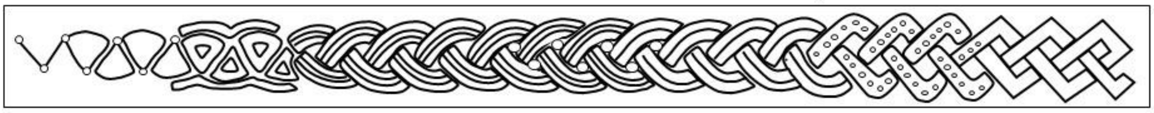
Euclid wrote 13 volumes on Geometry in his 'Elements', much of which was based on these earlier documents from other cultures. However he also made a huge creative contribution in developing the various theorems, all of which followed from the five postulates he had identified. The fifth one concerned parallel lines and could not be proven, and it took until 1729 before it was re-stated by John Playfair.



Using a straight edge, compasses and a pencil it's easy to bisect an angle and to contruct numerous Polygons. However it is not possible to trisect an angle or to construct a seven sided polygon with these items. Nevertheless the trisection problem was solved using a straight edge with a graded scale in an instrument called a Neusis as shown above. With these drawing techniques and the newly identified Euclidian theorems, it became possible to create very complex geometrical ornamental designs, and this was taken to its ultimate limit in the Middle East 1200 years later in The Middle East.

Interlace and Knot-work

Byzantine-Celtic   Turkish 15th Century *(After George Bain 'Celtic Art')*



Pictish   Greek-Celtic   Persian

Roman Interlace Mosaic
AD 325 Gloucestershire

Galicia 'Torc'
300 BC

Hausa Architecture
West Africa

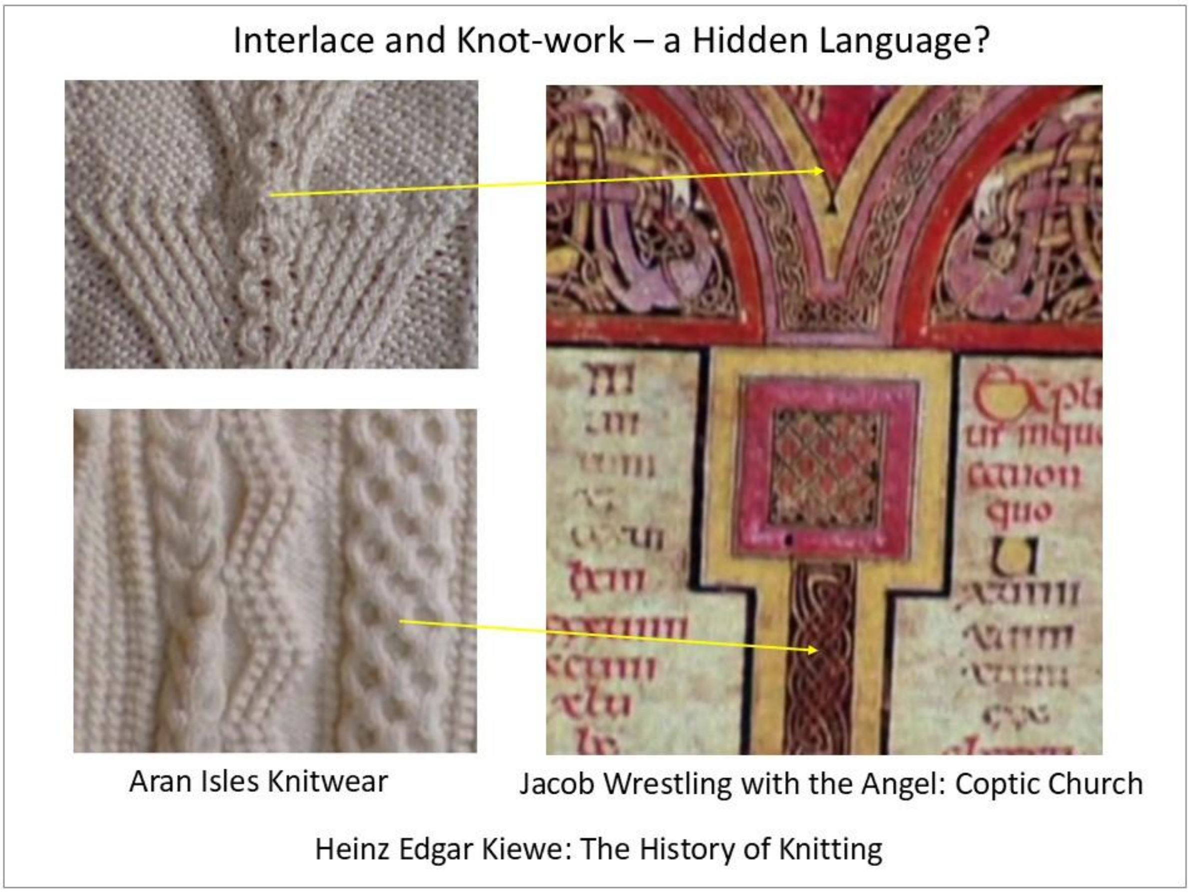
A physical knot has been defined in the 'Ashley book of knots' as 'an intentional complication in cordage which may be practical or decorative, or both'. Though knots originally served purely practical purposes, it's a creative inevitability that they would soon become an art form, and different kinds of knotwork can be found in many cultures going back to very early times. The Torc shown above is a necklace usually worn by women of high ranking and examples have been found from as far back as 800 BC. Hausa architecture in Africa is adorned with various designs resembling Celtic knotwork, but there's no reason to suggest that these design were not invented independently.

The Celts however took this art form to its peak with the most elaborate interlacing that was often combined with other forms of ornamentation such as calligraphy (eg The Book of Kells). Individual Celtic knot designs are highly symbolic and have specific meanings, for example The Trinity Knot, representing the Holy Trinity, Solomon's Knot representing wisdom, The Dara Knot inspired by oak tree roots, representing strength. Also the the apparent endlessness of the designs and their inter-lacing relate to the interconnectedness of life and eternity.

The Irish film-maker Bob Quinn produced a series of documentaries in the early 1980's concerning an alternative theory on the origin of the Celts. The received view was that the Celts were based in central Europe as far back as 1200BC, and much later in history as a result of invasions by other tribes they were driven to the Western fringes of France, the UK and Ireland. Bob Quinn however found sufficient evedence based on cultural artefacts and practices such as dancing and singing styles, to suggest they had arrived to the Western shores by boat from North Africa.

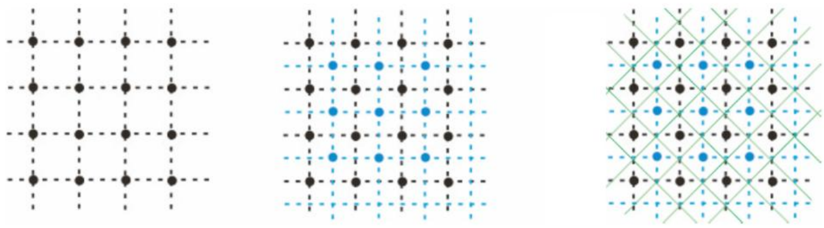
In this extract from one of his documentaries, he shows how knotwork used in knitted Aran sweaters was used in pre-literate times to preserve stories:

https://www.youtube.com/watch?v=eTEwsPqsNgg

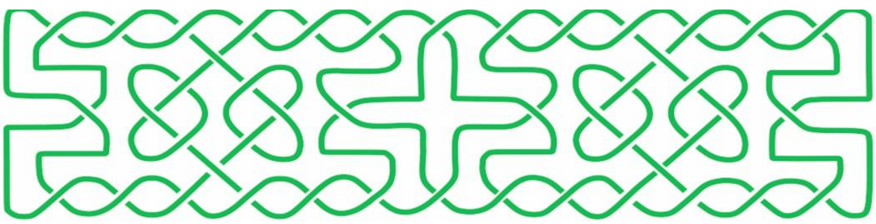


The construction of Celtic Knotwork is based on the use of three grids and a set of simple rules. A couple of constructions are shown in this video:

https://www.youtube.com/watch?v=Mw1D4KUUBGE



Primary Secondary Tertiary



The addition of ‘Stops’ in the grids enables more elaborate designs.

By the 1^{st} century AD most Celtic territory had been integrated with the Roman Empire and a few hundred years later only a few pockets of the culture remained intact in Britain, Ireland and France.

The next major development of geometry in ornament appeared about 1500 years ago and 200 hunderd years after the birth of Islam.

Typical Islamic Geometric Designs

A renaissance took place in the Middle East and Central Asia during the 8^{th} and 9^{th} century prompted by translations of ancient texts from Greek and Sanskrit languages. The development of geometry in Islamic art and architecture - appearing about 200 years after the birth of Islam - was an outcome of this new growth in science and technology. The earliest written document on geometry in the Islamic history of science is that authored by the polymath Al-Khwarizmi in the early 9th century of the Common Era.

Islamic geometric patterns were initially derived from simpler designs used in earlier Greek, Roman, and Sasanian (Iranian) cultures. Again they are one of three forms of Islamic decoration - the others being the arabesque based on curving and branching plant forms, and Islamic calligraphy. However over time, icons (ie organic ornament) that could become objects of worship were given less emphasis. Comsequently from the 9th century onwards, the sophistication in geometric patterns based on interlocking polygons eventually become the dominant form of ornamentation.

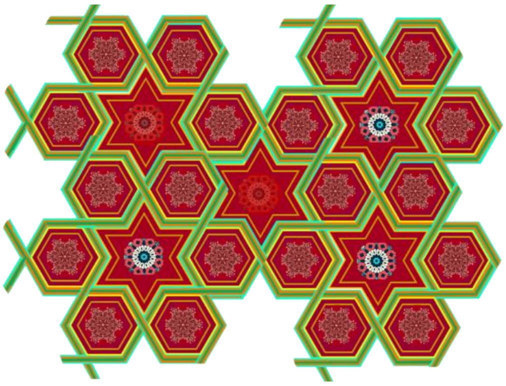
Most Islamic patterns are designed by starting with a circle symbolising unity, and the writer Keith Critchlow argues that Islamic patterns are created to lead the viewer to an understanding of the underlying reality, rather than being mere decoration.

The sculptor, graphic artist, photographer and author David Wade states that "Much of the art of Islam, whether in architecture, ceramics, textiles or books, is the art of decoration - which is to say, of transformation." Wade argues that the aim is to transfigure, turning mosques "into lightness and pattern", while "the decorated pages of a Qur'an can become windows onto the infinite."

The complexity and variety of patterns used evolved from simple stars and lozenges in the ninth century, through a variety of 6- to 13-point patterns by the 13th century, and finally to include also 14- and 16-point stars in the 16^{th} century.

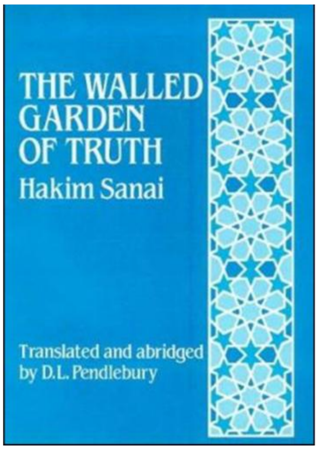
For more detailed information on Islamic geometry, the interested reader may wish to read the works by David Wade located here: https://patterninislamicart.com/texts-and-essays

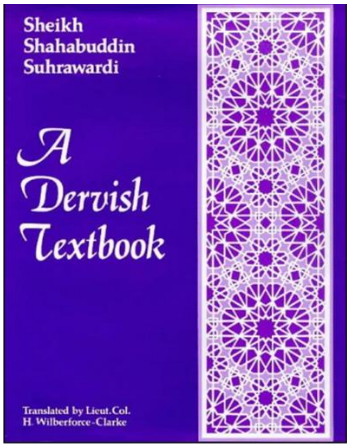
Quite complex Islamic geometric constructions can be made using just a compass and straight edge, and the video shown here demonstrates how a multitude of shapes begin to appear when the hexagon (derived from a circle) is repeated: https://youtu.be/gMHPLq0gHJ0

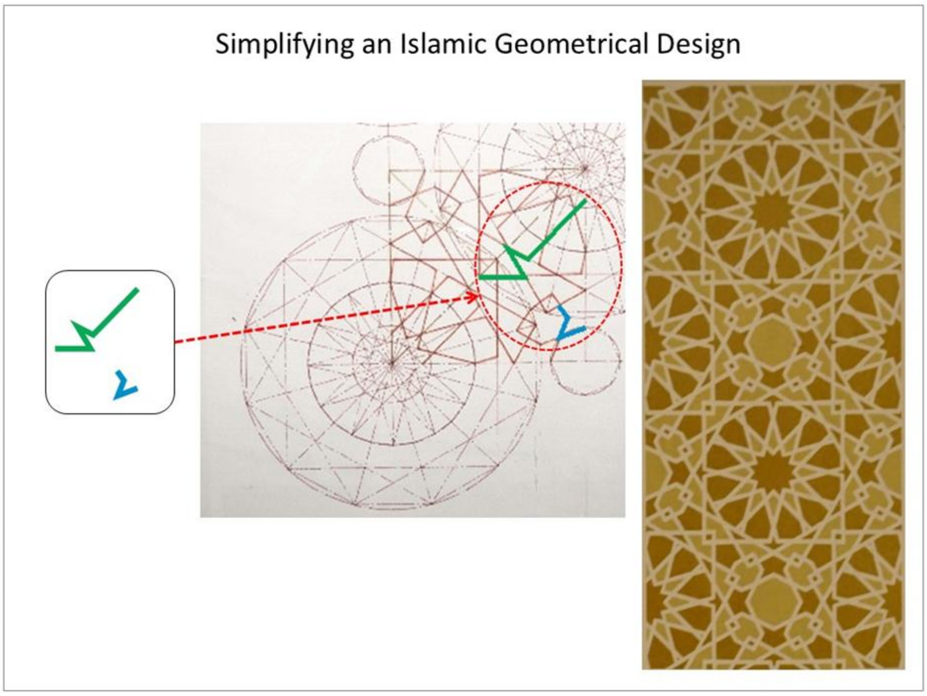


A simple Islamic geometric design with additional ornamentation

Some years ago the author developed a desktop LASER cutting device for making stencils. One of the projects with this technology involved making lithographic printing masks of Islamic geometric patterns for a variety of book jacket designs. The book publisher was ‘Octagon Press’ and two examples of the jackets are shown below:

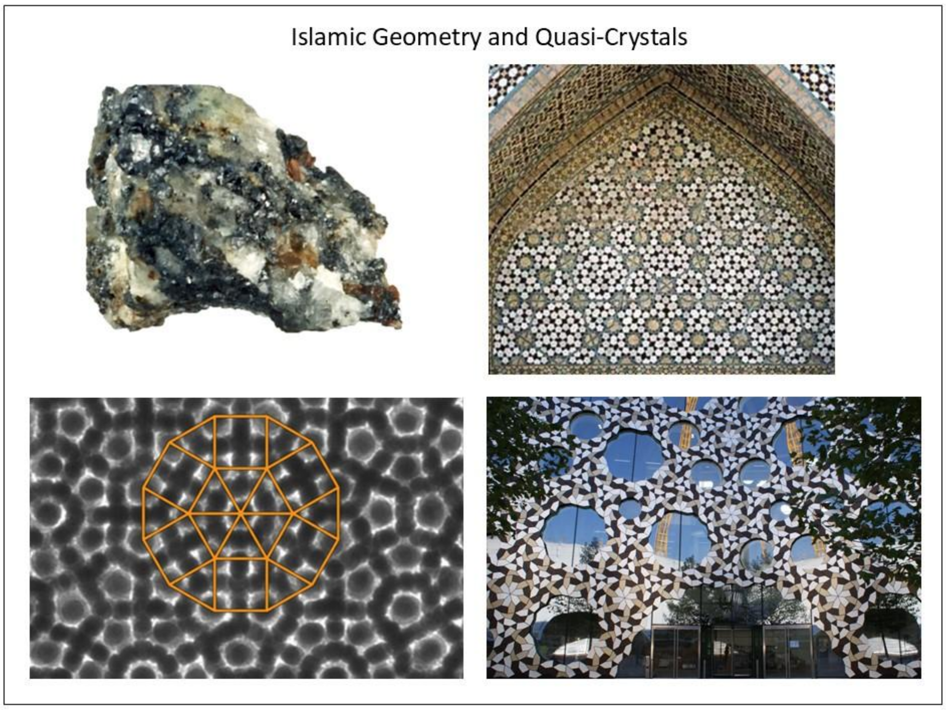






Whilst designing one of the Islamic geometric patterns, it was observed that the entire design could be produced from two very simple elements. This was achieved through a combination of rotations, translations and mirror-imagings of these basic elements. This speeded up the design considerably and the video here shows this process in action. https://youtu.be/vOwqTJZD7_A

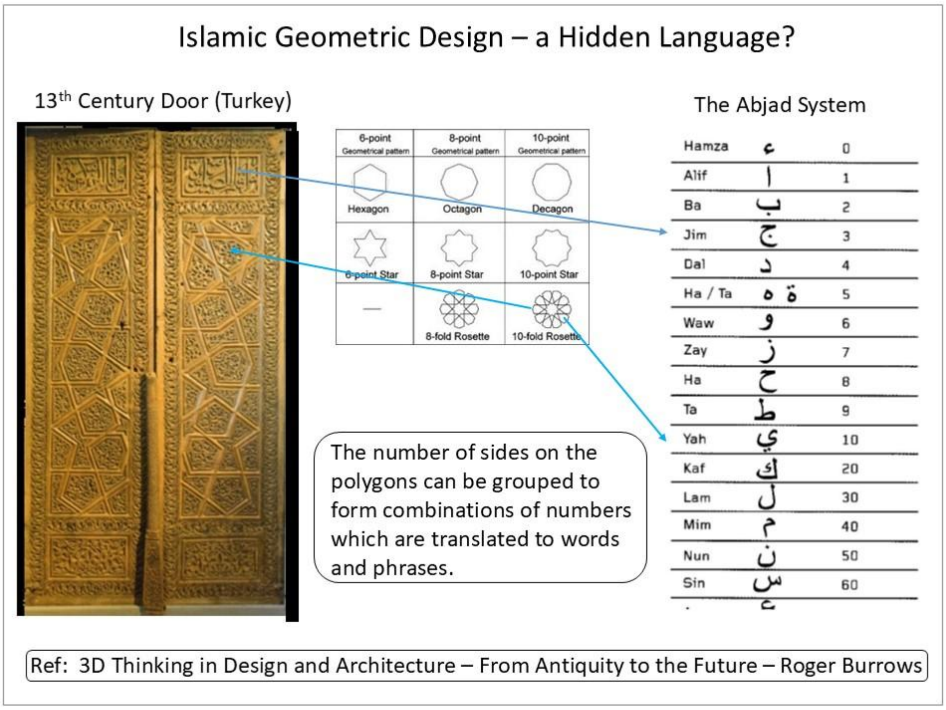
These transformations are used by crystallographers when deciphering x-ray interference images of unknown structures such as crystals or proteins.



Interestingly by about the 13th century, when these geometric designs were becoming more complex, it was discovered that some designs could not be easily constructed using only a straight edge and compass. In fact they were designed using a system of tiling known as ‘girih’. Two scientists Lu and Steinhardt (see reference below) showed that the tiles were produced from combinations of a set of shapes ranging from pentagons to bow-ties. These tiles however could be constructed with techniques developed using geometry. Using a set of rules with these basic tile shapes it was possible to construct very complicated patterns, and by the 15th century, the tessellation approach was combined with self-similar transformations to construct nearly perfect quasi-crystalline Penrose patterns, five centuries before their discovery in the West.

An example of a quasi-crystal is shown above alongside a girih design on the Darb-i-Imam shrine in Isfahan, Iran which was made in 1453, and is almost identical to a Penrose tiling. Although the pattern looks regular, like a quasi-crystal, it never repeats exactly. The lower two figures show an x-ray diffraction pattern of a the quasi-crystal discovered recently and theornamentation of the front wall of Ravensbourne College in Greenwich which is a Penrose tiling.

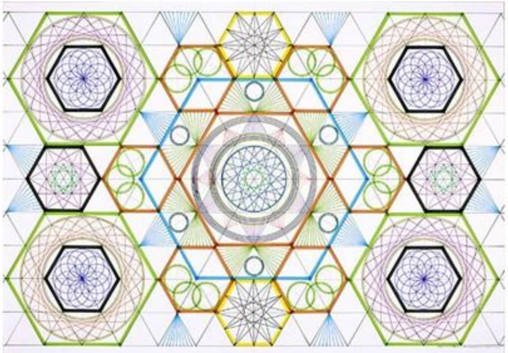
Reference: Lu P. J. & Steinhardt P. J.. Science, 315 . 1106 - 1110 (2007).



The number of sides on polygons in Islamic geometric designs, in combination with numerical values assigned to letters of the Arabic alphabet, were used to encrypt messages to those who knew how to decode them. The mechanism of encryption involved transcribing shapes and letters into numbers, and then applying a set of rules to the numbers (eg multiplying by 10, or re-arranging their order) in order to generate new numbers, which were in turn transcribed back to new words. An example of this is shown above with the geometric and calligraphic ornamentation on a 13th century door in Turkey. According to a study by Roger Burrows in his book '3D Thinking in Design and Architecture – from Antiquity to the Future', the door was the entrance to a hall where the Whirling Dervishes practised and the there are numerous clues to this, encrypted by the aforementioned numerology and also in the geometric shapes on the door.

This final section explores the use of geometry as art rather than ornament which requires another big jump forward in history to the 20th century. At the same time as concluding the section on Islamic geometric design and moving on to the final section, three examples of work featuring geometry 'inside the frame' shown in gallery spaces, are given below.

Modern Islamic Art



Monir Shahroudy Farmanfarmaian

Philip Taaffe

Susanna Lisle

Monir Shahroudy Farmanfarmaian was the first to combine the geometric patterns and cut-glass mosaic techniques of her Iranian heritage with the emerging styles of Western geometric abstraction. When she visited the Shah Cheragh mosque in Shiraz, Farmanfarmaian described the experience as transformative and said:

"The very space seemed on fire, the lamps blazing in hundreds of thousands of reflection ... It was a universe unto itself, architecture transformed into performance, all movement and fluid light, all solids fractured and dissolved in brilliance in space, in prayer. I was overwhelmed."

With regard to the symbolism of the hexagon she also stated:

"At the centre of this geometry, for me, is the hexagon. The mosques in Iran, with the flowers and the leaves, are based on hexagons. Islamic rugs are based on hexagons. The hexagon reflects the six directions—forward, backward, right, left, up, down – but it also reflects the six virues of generosity, self-discipline, patience, determination, insight and compassion. It can connect everything…"

Philip Taaffe Another artist who has worked with Islamic geometry Taaffe mixes cross-cultural references to make layered artworks that bring the past into the present. Here's an extract of an interview by the art curator Diego Cortez:

Cortez: You've gone historical as opposed to futurist. Most art is concerned with the new - a new production of new things in new times. I feel you largely reject these notions of the new.

Taaffe: Essentially, I'm trying to make a primitive painting. I'm trying to summon the archaic. I want to enter into a primitive situation. This is my protest against the sensory deprivation that we experience, which is due to this tendency towards globalization, towards homogenization, towards the generic - a technological standard rather than an aesthetic standard. I'm mining history, trying to regenerate a pictorial situation that is more humanistic. It's not about commodification, it's not about fitting into some sort of corporate structure. It's opposed to that direction.

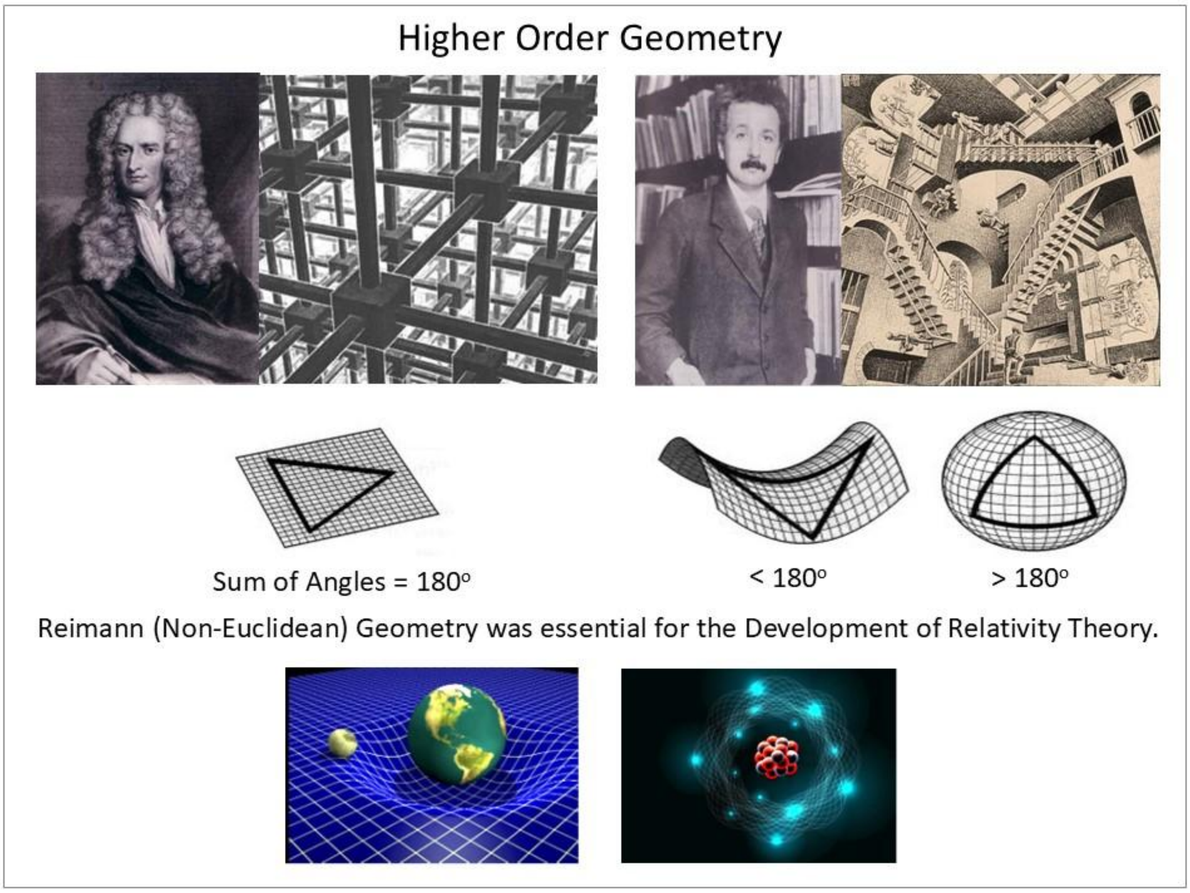
The full interview can be read here: https://www.interviewmagazine.com/art/philip-taaffe#

This desire for the primitive identified in geometric shapes is a perennial theme in modern geometric art as described later and is strongly connected with the sense of another dimension - 'the spiritual' – from which we have become seperated, in this case due to modernity.

Susanna Lisle has introduced Islamic geometric designs in her art work which: "Looks at the interplay between organic form and mathematical language - exploring the idea that geometry and pattern can be metaphors for the visual world and one's experience of it. To quote from her writing on this subject (https://www.susannalisle.com/):

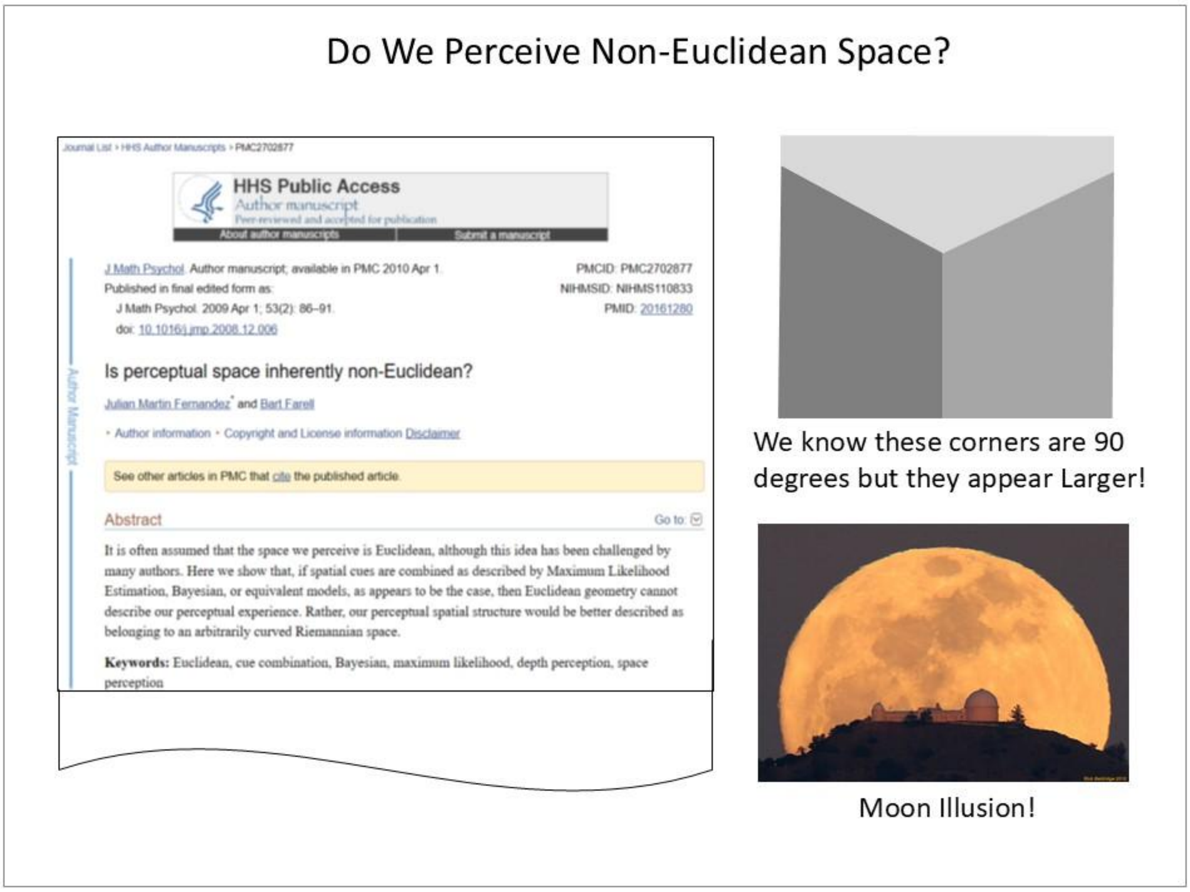
"I see Galileo's remark that 'The book (of nature) is written in mathematical language...' as a true statement, offering endless possibilities of explanation in visual terms. These magical complex systems are reflected and replicated in hedgerows or winter branches or flower structures.

I have used Islamic pattern particularly to explore these ideas of metaphor and correspondence. I am interested that it is possible, from the simplest geometry, of circles, squares and triangles, a multitude of complex worlds can mutate. The forms which arise are untethered to any cultural aspect and are free to become useful components in each painting or drawing. Within each work, geometry and pattern are hopefully at play with other painting traditions."



Continuing this shift of emphasis on geometry towards art rather than ornament, the revolution in science at the turn of the 20th century precipitated a disruption in art too. In 1905 Albert Einstein published five scientific papers that changed our understanding of physics, leading to the development of two major theories - quantum mechanics and general relativity - that have been the greatest influence on science and technology in human history. In order for Einstein to develop these ideas he needed to apply a new form of geometry that had been discovered fifty years earlier by Bernhard Reimann. This geometry was non-Euclidian and dealt with spaces that are not flat. All the theorems of Euclidian geometry apply only to flat planes, for example where the interior angles of all triangles always add up to 180^o. However, if the points of a triangle are on a convex, curved (Reimann) surface, the angles add up to more than 180^o and if the surface is concave, less than 180^o.

In effect Euclidian geometry is a special case of Reimann geometry, in the same way that ordinary numbers are a special case of multi-dimensional numbers known as tensors. Einstein introduced a more comprehensive description of space and time (which incorporates curvature in space-time) with relativity theory, for which the earlier physics of Newton was also a special case. This special case is the world we inhabit, so this raises the question of whether or not we could find any meaningful symbolic value in artefacts that are not Euclidian.

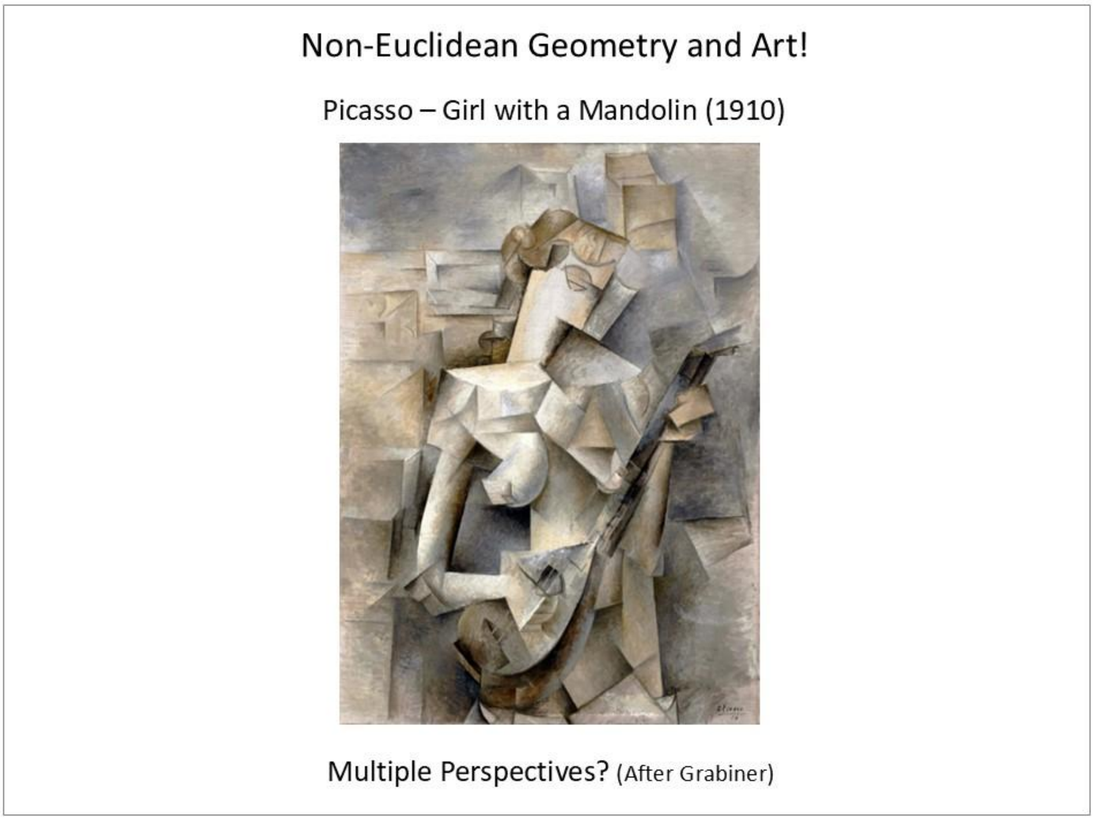


The aforementioned question might be partly answered by the publication shown above that enquired whether we see the world as Euclid described. Simply looking at the corner of a room will demonstrate that this is not the case. Even though we know the angles are 90^o, we see them as larger. This is one of several illusions that our perceptions are subject to, and the Moon illusion is another. When we view the Moon on the horizon it appears to be much larger than when it is overhead. This is clearly not factually correct and the reason for the illusion is that the horizon acts as a reference point against which we unconsciously scale the size of other objects. This mechanism in our vision processing would have provided a survival advantage during early evolution in gauging the threat of a predator for example.

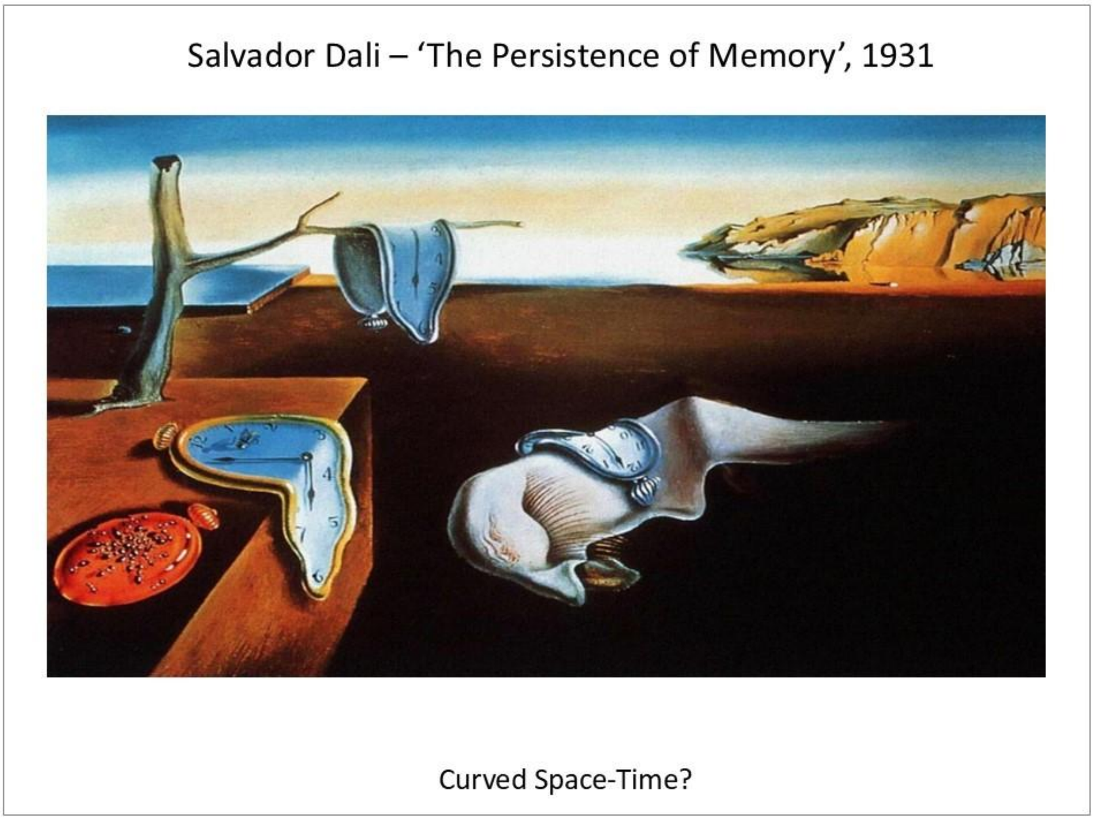
Without going into too much detail, it's useful to mention at this stage the idea of 'The Imaginal' as distinct from the imagination and this is decribed clearly by Cynthia Bourgeault when she says: "It (the Imaginal) is traditionally understood to be a boundary realm between two worlds, each structured according to its own governing conventions and unfolding according to its own causality. Put more simply, it separates the visible world from realms invisible but still perceivable through the eye of the heart."
Reference: https://www.cynthiabourgeault.org/blog/2018/11/13/introducing-the-imaginal

The following three images are examples of modern art that appear to have been informed and inspired by contemporary scientific ideas emerging at about the same time. Picasso's 'Girl with a

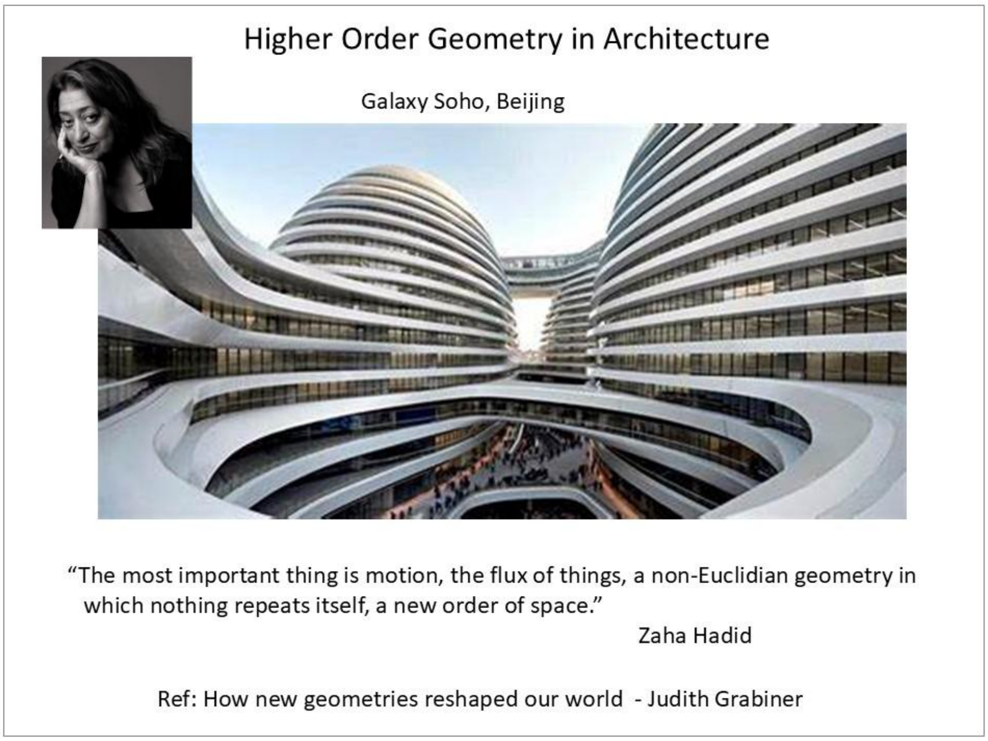
Mandolin' has been interpreted by Grabiner as a representation of Einstein's Special Relativity theory where the same figure is viewed from different space-time frames.



Dali's 'Persistence of Memory' depicts a simple representation of Einstein's General Relativity which discusses curvature in Space-Time,

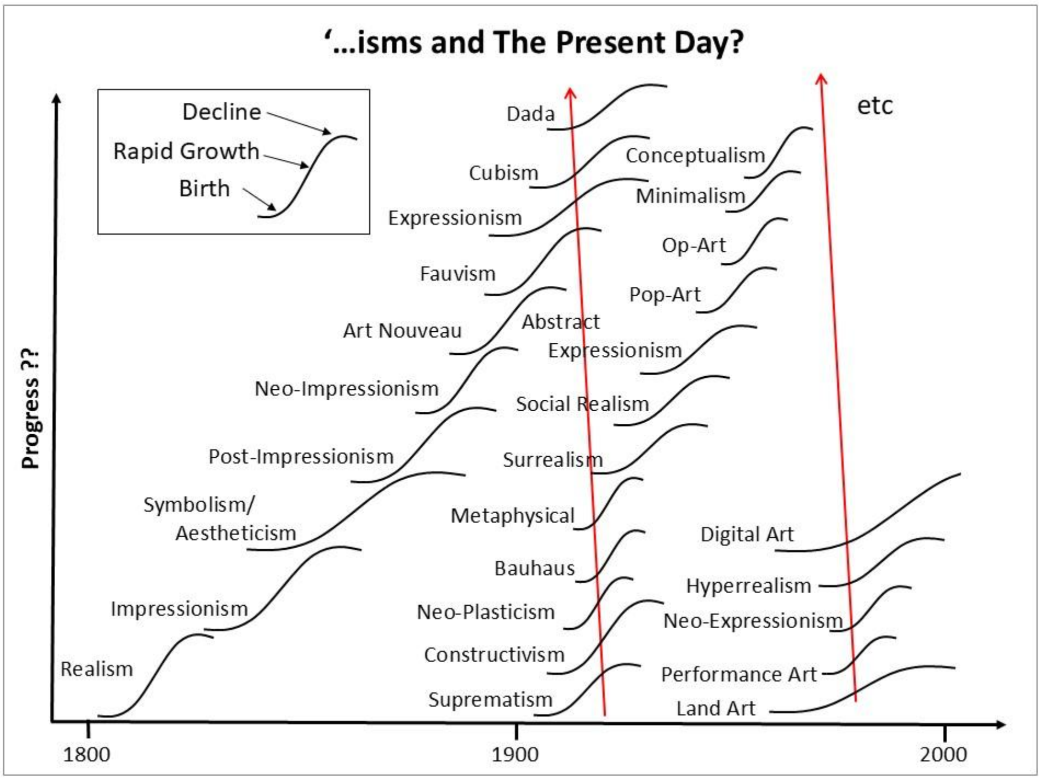


Zaha Hadid introduced the concept of higher order geometry in her architectural designs:



When Impressionism eventually became an accepted, and new way of seeing the world by including not just static figures, but the effects that light and its changing qualities had on the subject matter; it inspired a lot of experimentation by artists on other ways of seeing. Impressionism is partly abstract art and a proliferation of different forms of abstract art (ultimately pure abstraction) eventually followed in which shape and colour is given to thought and feeling.

All things that are subject to temporal change undergo the three stages of birth, maturity and death, and in the world of technological innovation this has been characterised by a stretched out 'S' curve (sometimes called a Sigmoid curve). Applying this to art history, a snapshot is given below of many of the recent art movements viewed as 'S'-curves. The following images are selected from some of these movements that have in common the inclusion of geometric forms in their subject matter. So geometry is now 'in the frame' as it were rather than being confined to an ornamental role.

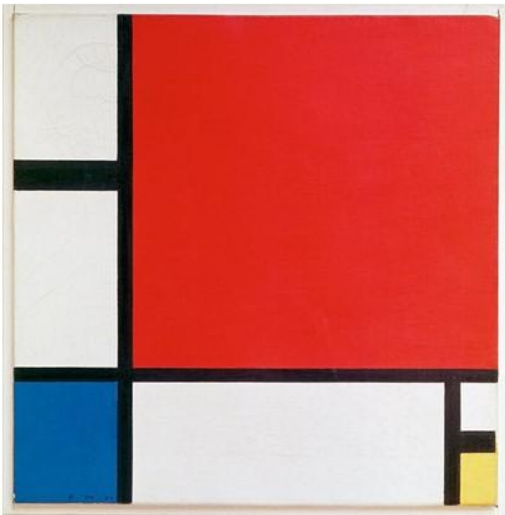


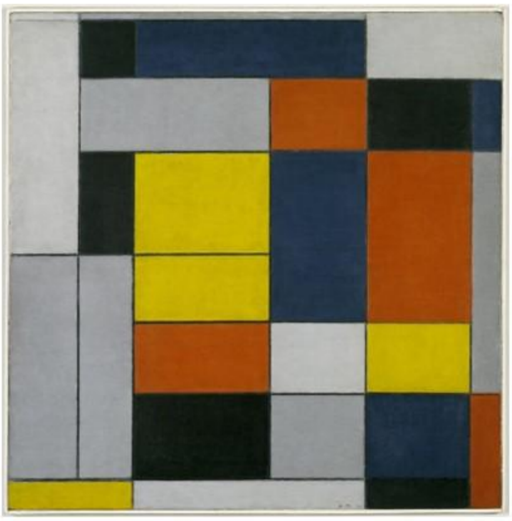
Included in the images are quotes by the leaders of these movements that relate to the use of geometric figures.

Cubism – George Braque 'Maisons et Arbre' (1908)

"…….reducing everything, places and figures and houses, to geometric schemas, to cubes" *Louis Vauxcelles on George Braque*

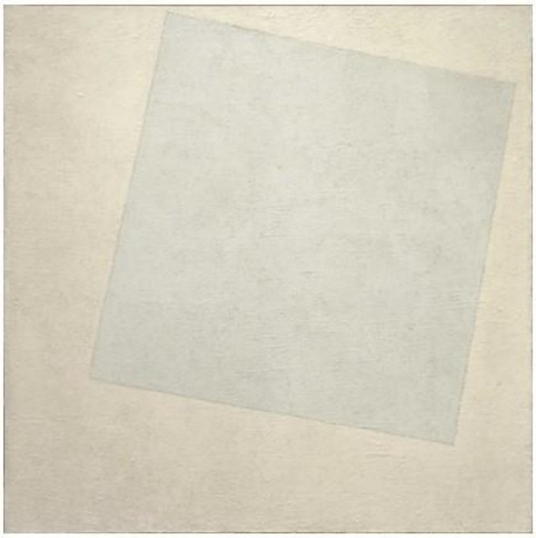
Neo-Plasticism (New Art) - Piet Mondrian No. VI / Composition No.II (1920)



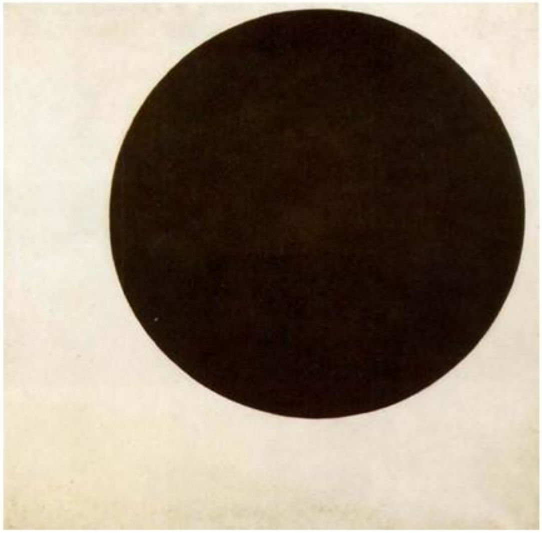


The rhythm of relations of colour and space makes the absolute appear."
Piet Mondrian

Suprematism



Malevitch – White on White (1918)

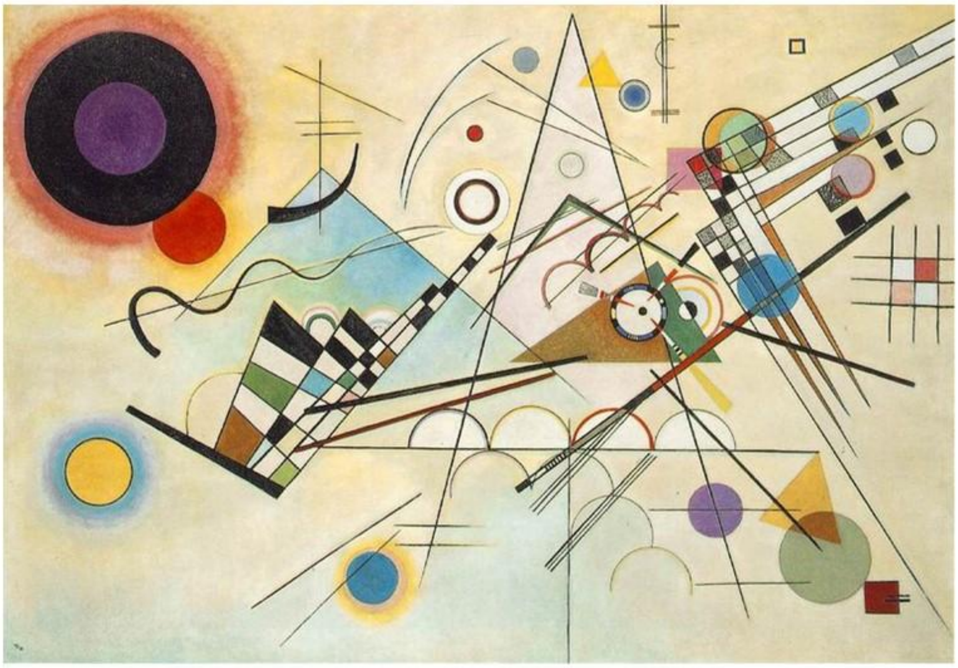


Malevitch - Black Circle (1915)

"……the supremacy of pure artistic feeling rather than on the visual depiction of objects."

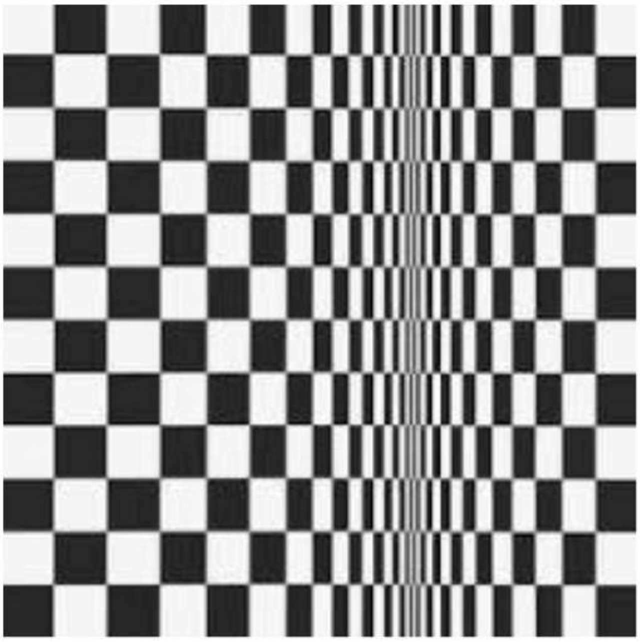
" In the year 1913, trying desperately to free art from the dead weight of the real world, I took refuge in the form of the square." *Kasimir Malevitch*

Vassily Kandinsky - Composition 8, (1923)



"….form itself, even if completely abstract, resembling a geometric form, has its own inner sound." *Kandinsky*

Op Art: Bridget Riley 'Movement in Squares' (1961)



"I couldn't get near what I wanted through seeing, recognizing and recreating, so I stood the problem on its head. I started studying squares, rectangles, triangles and the sensations they give rise to." *Bridget Riley*

It's interesting to enquire on why geometry became important to these artists and this is summarised in the quotation below by George Bain:

The Shock of the Ancient!

Paraphrased quote of George Bain - Author of 'Celtic Art'

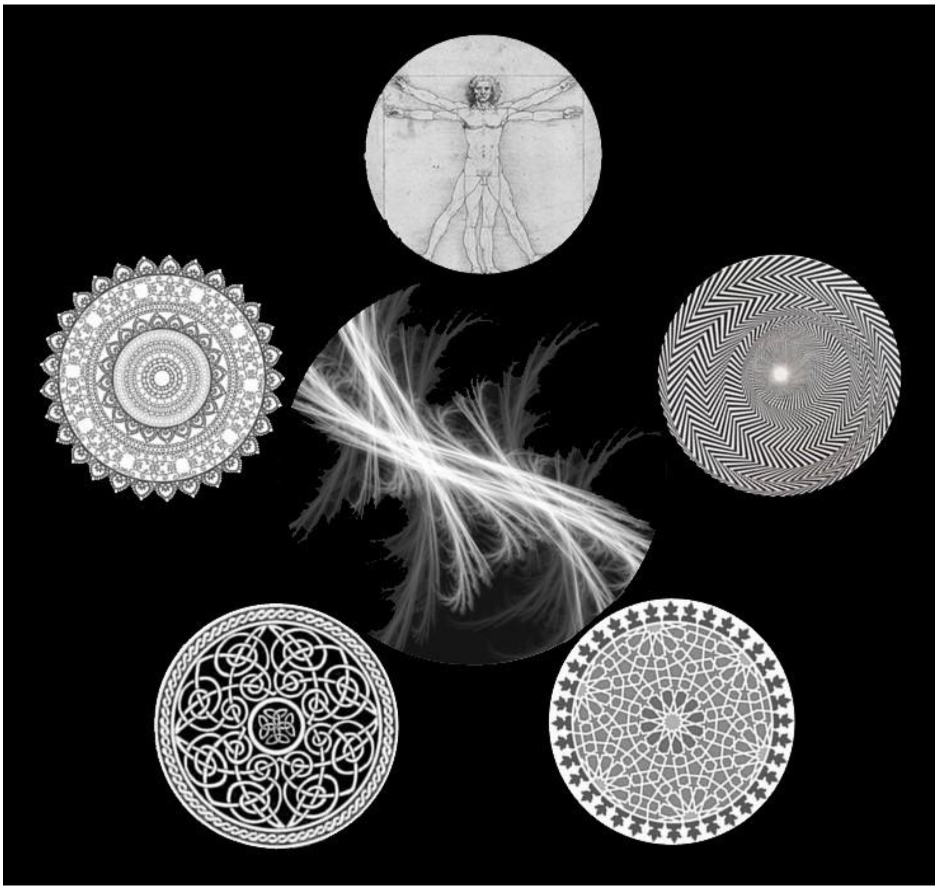
Modern Art is sometimes a form of primeval probing for something lost. The tendency of some Western artists, when the power of realistic representation has been attained, is to no longer accept this as the final achievement of Art. The inability to change is death in Art; the power to change is life. The primeval searchings of the modern Western artists are merely the reversions to the mental traits of remote ancestors.

Hence such probing, usually done in a state of acute consciousness, leads subconsciously to abstractions that may be inherited racial memories of the great Celtic cultures and of the still earlier Paleolithic hunter-artists, who were probably the first of modern European humans.

As proposed in the introduction, one of the first overt indications of the emergence of consciousness in humans, was the creation of geometric figures inscribed or drawn on various surfaces. They were symbols of another world of qualities and essences we can apprehend, and are analogues of incomplete or imperfect equivalences in the real world.

Observing and studying geometry in art and ornament in the real world - wherever it appears - can enable us to re-connect with that abstract world ('The Good' as Plato defined it), in the same way that we can see beauty in nature, in spite of it being as Tennyson said - 'red in tooth and claw'.

As the 14th century philosopher of history - Ibn Khaldun - said: "Geometry enlightens the intellect and sets one's mind right". More generally on the arts in general, the great modern composer, Stephen Sondheim stated: "Art, in itself, is an attempt to bring order out of chaos."



About the author:

After graduating with a Ph.D in applied physics from the University of Hull, Kevin pursued a career in commercial research in telecomunications for some twenty five years. After developing a passion for education he undertook a career change and took up posts at the University of Leicester and then at Queen Mary, University of London.

He moved to Lincoln in 2014 where he is a freelance research skills developer working with Ph.D students at a number of higher education institutions in the UK and Europe.

Shortly after moving to Lincoln he was involved in organising a series of art lectures and was elected a trustee of the Sam Scorer Gallery, The Usher Gallery in Lincoln and The St Hugh's Foundation. He has presented two lectures on art on the subject of 'What Inspires Art?' and 'Geometry in Art and Ornament' to the Friends of the Feens Gallery in Hull and to other groups and societies.

He has published widely on his earlier research interests, and more recently on creativity. In 2023 he compiled, edited and published the book 'What Inspires Art?' which is a collection of art and stories addressing this question authored by 110 Lincolnshire-based artists. He currently manages a series of open art exhibitions and art talks in Lincoln: https://www.open-art-lincs.com/

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