The Mathematician and the Artist

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"The universe (which others call the Library) is composed of an indefinite, perhaps infinite number of hexagonal galleries.[...] The Library is unlimited but periodic. If an eternal traveler should journey in any direction, he would find after untold centuries that the same volumes are repeated in the same disorder - which, repeated, becomes order: Order. My solitude is cheered by that elegant hope." - Jorge Luis Borges, *The Library of Babel*

A painter, a composer and a mathematician share a creativity that allows them to illustrate their perception of the universe. It is important to notice that even though their understanding of the universe and the medium they choose to use to depict it may differ, the order and structure of their idea may be perceived by some to possess a chaotic beauty. Thus, the disordered nature of the impressions made by a mathematician on a page can be compared to the strokes of paint on a canvas, or the embellishment of quavers, crotchets and minims on a musical score. G.H. Hardy was one who recognised the resemblance of the thinking of the mathematician and the artist which is evident in his autobiographical account, 'A Mathematician's Apology' (1940). Throughout his book, Hardy suggests that real mathematics is "almost wholly useless" (Hardy, 1940), but its significance in areas such as applied science, art, music and poetry, highlights the inevitability of its beauty. Just as Hardy recognised the artistic qualities of a mathematician by describing them as a "maker of patterns" whose "ideas like the colours [...] must fit together in a harmonious way" *(ibid)*, M.C. Escher and Olivier Messiaen believed in the value of mathematical thinking that can clearly be seen to dominate the majority of their paintings and compositions.

The Mathematician and the Painter

The mathematician and the painter are intellectually and creatively connected by their capability of illustrating the beauty of mathematics, thus "mathematics and fine art painting are two examples of the human consciousness striving to comprehend reality" (Jensen, 2002). Both the mathematician and the painter derive their inspiration from mathematical theorems and ideas, which are then interpreted in a way that would allow their audience to digest. Therefore, the painter is able to metaphorically interpret mathematics as well as represent the physical world on a two-dimensional surface.

"Ars sine scientia est nihil" (Ghyka, 1946)

The motto above was adopted by many of the artists of the Renaissance including Filippo Brunelleschi, Leonardo Da Vinci and Albrecht Dürer. It is evident that an important element of art is geometry, so without the mathematics of geometry there is no art or idea of what we perceive to be beautiful. An artist who had a strong fascination for mathematics, influenced by the teachings of Plato and Fibonacci, and who incorporated geometry, as well as the Golden Ratio, was Leonardo Da Vinci. One of his most famous artworks is the 'Vitruvian Man' (c.1490) which is a drawing, accompanied by some notes from the 1st century Roman architect Vitruvius, that can be interpreted as a metaphorical solution to the squaring-the-circle problem. This problem was proposed by ancient Greek geometers, whereby the objective was to construct a square with the same area as a given circle. 'Vitruvian Man' is a drawing of a man with his arms and legs spread out. The idea was that the arm span and the height of a man have an almost perfect correspondence, which allows the figure to be inscribed in a square. Da Vinci believed that the navel marks the centre of the human body and so using a compass he drew a circle around the Vitruvian Man so that the feet and fingertips touched the circumference, and the navel was the centre. This belief was very common in this period particularly amongst the neoplatonists whose key belief was in the great chain of being with man at the centre of this chain ; the centre of the universe (Ghyka, 1946). The ‘Mona Lisa’ (1503) is another famous example of Leonardo Da Vinci’s use of geometrical proportion to emphasise attractive features. The structure of this painting is built on the Golden Ratio as it is possible to tile the painting with rectangles, such that the ratio between the width and length is equal to $\frac{1+\sqrt{5}}{2}$, and this harmonious relationship is what makes this painting remarkably captivating. Mathematics as an explanation of what we perceive to be beautiful is also very relevant in the world around us, especially in nature such as the symmetry in an organism’s phenotype, or the rhythmic patterns of starling murmurations. In ‘The Geometry of Art and Life’ (1946) Matila Ghyka observes the “artist as planning his work of art according to a pre-existing system of proportions” which suggests that the artist's ideas are mathematically inspired. Luca Pacioli, Da Vinci’s mathematical correspondent, called the Golden Section “The Divine Proportion”, and through their collaboration they produced the manuscript ‘De Divina Proportione’ (1509) in which Da Vinci produced illustrations of geometrical shapes ,some of which are believed to be the first drawings of polyhedra using solid edges and hollow interiors.

With proportion comes perspective, as a key principle for the representation of an object on a canvas without altering the ratios of measurements is perspective. Da Vinci was one of the first artists to use linear perspective, and Filippo Brunelleschi was one of the key pioneers for the mathematical development of perspective in art (O’Connor, 2003). Before the 13th century, the discussion of perspective in art was limited to the ideas adapted by Hellenistic architects and artists who would create the illusion of depth in their work, but the laws and guidelines for the formulations of these illusions were unknown. Renaissance artists strived to expand on this by constructing a solution to the problem of representing a three-dimensional world on a two-dimensional surface. In truth, the act of answering an age-old question to paint a beautiful solution forms part of the foundations of mathematical thinking, hence it would be appropriate to label these artists “secret mathematicians” as Marcus du Sautoy did (du Sautoy, 2014). Brunelleschi’s understanding of the relationship between the actual measurements of an object and its measurements in a painting, mathematically defined as “scale”, marked the beginning of the laws for painting the “whole” universe on a canvas with finite dimensions.

Demonstrations of these laws being practiced can be seen by 19th century artists such as Van Gogh, for example in his ‘Bedroom in Arles’ (1888) we get the impression of depth as the headboard is small relative to the foot of the bed. Moreover, Edgar Degas’ unusual use of large open spaces at the edges of ‘The Green Dancer’ (1879) and ‘The Ballet Class’ (1874) creates the illusion that the ballerinas will eventually move into that space. He almost mathematically positions the ballerinas on the borders of his paintings with their arms and legs cut off at the frame to give the audience the feeling of being infinitely stuck in that moment of time, infinitely waiting for the next. M.C. Escher was also an artist who dealt with perspective as shown in ‘Up and Down’ (1947) where he uses unusual vanishing points, in the top and bottom left and right, to render scenes where the up and down, left and right orientations would keep shifting everywhere you looked. Both the mathematician and the artist have meaning behind their work masking their passion for discovering the structures on which the world is built on; one can derive meaning from Monet's "broken colour" technique, as well as Plato's geometrical reconstruction of the universe using regular polyhedra. Therefore, the motive of an artist's use of geometry can simply be explained by the fact that "Art without knowledge is nothing" (Ghyka, 1946).

Modern artists have used classical and ancient Greek mathematics to represent how they see the world. By doing this they are forced to see the world through the eyes of a mathematician, and may therefore adopt the logically deductive thought process of a mathematician in their planning. In this way, both mathematics and art will forever be renewed or discovered by individuals seeing the world from a perspective that has never been considered before.

The correlation between mathematics and art is believed to have begun with the Pythagoreans. The Pythagorean creed "Everything is arranged according to number" (Ghyka, 1946) has a similar tone to the motto stated above, and, similar to the motto above, suggests that knowledge and mathematics are the foundation of everything. In fact, several hundred years later, Plato sought inspiration from this Pythagorean creed, helping the development of his own ideas about the geometry of the universe and the role of mathematics in the explanation of its order and beauty. Matila Ghyka wrote in 'The Geometry of Art and Life' (1946):

"[...] Plato's Aesthetics, his conception of Beauty, evolved out of Harmony and Rhythm, the role of Numbers therein, and the final correlation between Beauty and Love, were also bodily taken from the Pythagorean doctrine [...]".

Perhaps our perception of what is beautiful and what isn't is dependent on the question of the subject's mathematically harmonious qualities. Am I captivated by Van Gogh's 'Starry Night' (1889) due to the juxtaposition of light and dark, near and far, real and imaginary, or the artistic representation of turbulence generated by the prominent brushstrokes that make up the swirls in the night sky? If you stare at this painting long enough, you might begin to get the sensation that the clouds are moving and dancing around the stars. This method of illusion is very common amongst artists especially impressionistic, expressionistic and modern artists. For example M.C. Escher used metamorphosis in the vast majority of his artwork to give the illusion of an object endlessly transforming into another. In 'Reptiles' (1943), we see small creatures escaping from, or morphing out of, a two-dimensional tesselated drawing, into three-dimensional space and then circling back around. This is a clear illustration of his statement that "Man is incapable of imagining that time could ever stop", which he mentions in his essay 'Approaches to Infinity' (Escher, 1984), clearly showing us the limits of the human mind when trying or beginning to comprehend the universe, as well as a possible connection to Gödel's Incompleteness Theorem. From this piece of artwork alone, we can infer that Escher had a profound fascination with exploring dimensions and how they connect, in other words, how objects can travel through space and time. 'Reptiles' is a perfect encapsulation of all of Escher's sources of mathematical inspiration; metamorphosis, space, infinity and the Platonic Solids.

Escher's interest in the shape of space is evident in his pieces 'Three Intersecting Planes' (1954), 'Circle Limit III' (1959), 'Mobius Strip II' (1963) and 'Snakes' (1969). 'Circle Limit III' shows prints of fish that get smaller and smaller as they reach the edge of the circle, giving a curved effect. The illusion of a spherical image is an illustration of the concept of infinity because if you were to walk to the edge of this picture you would have to walk an infinite distance. This is just one example of a representation of a type of hyperbolic space called non-Euclidean space. 'Snakes' creates an effect opposite to 'Circle Limit III' because the print gets gradually and infinitely smaller as it tends towards the centre of the circle. Like a mathematician, in order to comprehend an abstract concept, they visually and metaphorically represent their interpretation of it, which also helps their audience to comprehend the complexities of space and infinity. In 'Mobius Strip II' M.C. Escher shows his fascination with topology by drawing a key object in topology; the mobius strip. Topology deals with the properties of space that remain unchanged when it is distorted, so if you were to trace the path of the ants on the mobius strip you would notice that they are all walking on the same side. Another piece where Escher explores topological space is 'Print Gallery' (1956) which shows a man in an art gallery looking at a seaside town which has an art gallery along the docks with a man looking at a painting of a seaside town. It is almost as if he has warped space and time and turned the gallery in on itself, as the man is both in the gallery and in the painting. This is an example of Escher's use of infinity, or loops, in his artwork. A loop can be described as different pieces of reality fitted together and played continuously. In 'Godel, Escher, Bach: An Eternal Golden Braid' (1979), Hofstadter explains this further by writing "one level [of reality] in a drawing might clearly be recognizable as representing fantasy or imagination; another level would be recognizable as reality". "The genius of Escher was that he could not only concoct, but actually portray, dozens of half-real, half-mythical worlds, worlds filled with Strange Loops, which he seems to be inviting his viewers to enter" (Hofstadter, 1979). If we were to analyse Escher's sketch for the preparation of this piece we would see a grid that bends and curves continuously in a clockwise direction. The importance of planning artwork is highlighted here, thus showing the similarity between the mathematician and the artist as a mathematician also needs to plan, research and produce rough sketches of their ideas.

Furthermore, Escher also represented his idea of the universe using the Platonic Solids. An important part of Plato's Mathematical Philosophy, as well as how he pictured the universe, was the Platonic solids (the tetrahedron, dodecahedron, cube, octahedron and icosahedron), particularly the dodecahedron which he believed to be "used for arranging the constellations on the whole heaven" (Ghyka, 1946). Extraordinarily, the Platonic Solids have been included in several hundreds of pieces of art including Dürer's 'Melencolia I' (1514), Salvador Dalí's 'The Sacrament of the Last Supper' (1955), and M.C. Escher's 'Stars' (1948). 'Stars' is a piece that shows many different stars that are formed by the intersection of polyhedra, specifically octahedra, tetrahedra and the cube, but a very curious addition is the position of chameleons inside them which may be intended to alarm the audience and create a "fresh" piece that isn't solely geometrical. M.C. Escher has been admired by mathematicians because of his respect for the subject, and the impression that he has understood that behind all mathematical ideas is the idea of never-ending “newness”, that new mathematics will continue to be discovered while the “old” mathematics will live on. The continued use of insects or reptiles in his pieces may be suggestive of Escher’s possible belief that mathematics is not only in art but in nature, hidden in the world around us.

Another artist, whose mathematically inspired work is important to consider, is Salvador Dalí. In his ‘Diary of a Genius’ (1963) we learn about his deep fascination with the rhinoceros, specifically its horn which he described as a perfect logarithmic spiral. Unusually, one could say that Dalí almost worshiped the rhinoceros horn because of how often it was featured in his artwork. For example, in his ‘Assumpta Corpuscularia Lapislazulina’ (1952) he creates a dialogue between God the Father, God the Son and the rhinoceros whose anatomical features can be seen surrounding the crucifix. The geometrical properties of the rhinoceros horn can therefore be symbolically represented as a raw product of the Creator. Thus, there is a divine quality of mathematics such that pure mathematical thought is believed to be fundamental to the artist’s representation of the universe. This is taken further as Dalí illustrated the similarity between the geometrical structure of the horn and molecules of DNA. In his ‘Portrait of Gala with the Rhinocerotic Symptoms’ (1954) the audience can see that her body is made up of shattered pieces of the horns of a rhinoceros. Additionally, Dalí noticed the presence of the horn, or logarithmic spiral, in other artist’s paintings. He states in his ‘Diary of a Genius’ that in Vermeer’s ‘The Lacemaker’ (1670) there is a close connection between the girl and the rhinoceros, as he writes “The Lacemaker is morphologically the horn of a rhinoceros”. From this, he has created his own representations of Vermeer’s painting, one such example is his ‘Persistence of Memory’; one of the most recognisable works amongst Surrealist artists. In his ‘Diary of a Genius’ he is suggestive of the presence of horns in ‘Persistence of Memory’ as he says “the same horns are already found in my paintings of soft clouds [...], rhino horns that come off and allude to the constant dematerialisation of this element [...], increasingly transforms my work into a distinctly mystical element” (Dalí, 1963). Dalí took this further and made a connection between sunflowers and the logarithmic spiral as he says “in the intersection of the sunflower spirals there is evidently the perfect shape of the rhinoceros horns” *(ibid)* which also highlights the connection between mathematics and the natural world.

Escher and Dalí are both artists that appreciate the value of mathematics in art, and have introduced mathematical thought into their creative routine. What connects them is their interest in metamorphosis, topology and dimensions. Metamorphosis is a little like topology where one object can be morphed or turned into another in a way that the two objects appear to be the same, or topologically equivalent. In Dalí’s ‘Swans Reflecting Elephants’ (1937) the reflection of the swans in the lake seem to be topologically equivalent to the elephants. Dalí’s passion for the fourth dimension is reflected in his ‘Corpus Hypercubus’ (1954) in which he attempts to illustrate the hypercube. In this piece the 4th dimension is used to communicate the transcendence of Christ and that he is part of a higher dimension that humans are not able to conceive. Hence, there exists elements of mathematics that are far beyond human comprehension, and so there will be theorems or conjectures that mathematicians will never be able to prove, or ideas that mathematicians will never be able to understand. Like the mathematician, Escher and Dalí are able to achieve the near impossible by their capability of understanding the universe.

The Mathematician and the Composer

The compositions of a mathematician and a musician, however complex, can be broken down into symbols, laws and theorems. Nonetheless, the building blocks of these compositions can only fit together if the artist possesses an imagination that gives a harmonious quality to their ideas. Hence, the "catchiness" of a piece of music, or the usefulness of a mathematical proposition derive their significance from the extent of the artist's imagination and the depth of their idea. In 'From Here to Infinity' (1996), Ian Stewart emphasises that "mathematics is about ideas", and "all good mathematics must contain an idea". This can be closely compared to music because one could say that all good music begins with a spontaneous idea that progresses into intricate markings on a page which is then performed for an audience. Similarly, Hardy famously stated that "there is no permanent place in the world for ugly mathematics" (Hardy, 1940), which is compatible with his notion that "languages die and mathematical ideas do not" *(ibid)*. The beauty of mathematics, and music, is therefore justified by the immutability of the composition and the inevitability of its future impacts. Just as Euclidean geometry continues to be taught in schools, Beethoven is still played on the radio and featured in modern films. Ian Stewart creates an association between the mathematician and musician by explaining that both mathematics and music can be appreciated from different points of view. He writes "Music can be appreciated from several points of view: the listener, the performer, the composer. In mathematics there is nothing analogous to the listener [...] it would be the composer rather than the performer that would interest him." (Stewart, 1996). Mathematics can also be appreciated from different points of view that are similar to that of music. There are those who enjoy maths, or hearing about maths, there are those who do maths or perhaps study maths, and there are those who we call mathematicians who devote their lives to mathematics and spend their lives as composers of mathematical music. Thus, the mathematician and composer share a passion for their subject that is a catalyst for their imagination and creativity. It is appropriate to say that there is mathematics in the works of Beethoven, Xenakis and Messiaen, and there is harmony in the thinking and reasoning of Pythagoras, Euclid and Archimedes.

"Music has always been, and continues to be, both sound and number, acoustics and mathematics, and this is why it is universal." (Xenakis, 1980)

Pythagoras is not only credited as the founder of the first mathematical institute, but also the first school of theoretical music. He was himself a music theorist who discovered the "fundamental correspondence between musical intervals" and the "first classification of consonant intervals" (Papadopoulos, 2014). All theories of harmony are built upon Pythagoras' discovery of the numerical ratios between notes, providing a justification for why the human ear can recognise harmony in certain groups of notes. A simple way to describe what is meant by the “ratios” or the relationship between musical intervals is to use the analogy of a length of taut string. If I were to pluck the full length of string, I would hear a sound or a single note. If I then halved the length of string and plucked it again, making sure it remained taut, I would hear the same note but an octave lower. Hence, the ratio between the notes of an octave is 2:1. A few thousand years later, Euler reached the same conclusion and remarks, in his ‘Tentamen novae theoriae musicae’ (1739), “that two or more sounds produce a pleasant effect when the ear recognises the ratio which exists among the numbers of vibrations made in the same period of time” *(ibid)*.

Treatises from the Hellenistic period were divided into four parts: Number Theory, Music, Geometry and Astronomy. This illustrates the usefulness of musical thought with regards to the development of mathematical thinking, which was even observed in a period of great mathematical discovery. Thus, one could say that there is a correspondence between the strategic approach of a musician and a mathematician, such that musical strategy, whose purpose is to revolutionise music, may also be of use for the discoveries of new mathematical ideas. For example, “the discovery of irrational numbers was motivated in part by the mathematical difficulty of dividing a tone into two equal parts. The distinction continuous vs. discontinuous arose from the attempt of splitting up the musical continuum into the smallest audible intervals.” (Papadopoulos, 2014). Astonishingly, there are some mathematical theories that were borrowed from music theory. In Euler’s ‘Introduction to the analysis of the infinite’ (1748) he describes to the reader how to find the twelfth root of two, and explains that it is equal to the value of the unit in the chromatic tempered scale *(ibid)*. There are many examples of how mathematics is used in musical compositions which will be discussed later.

“I made the same mistake that artists have made since the time of the Greeks, and placed mathematics alongside of the arts as their handmaiden. [...] But mathematics is the sister, as well as the servant of the arts and is touched with the same madness and genius. This must be known.” (Morse, 1950)

The “madness” and “genius” of the mathematician and the artist is what connects them in a way that one could describe them as “sisters”. Porphyry of Tyre writes, in his ‘Opera Mathematica’, a quote from Archytas’ book ‘On Mathematics’ that reads “The mathematicians seem to me to have arrived at true knowledge [...], they have handed down to us clear knowledge about the speed of the stars, and their risings and settings, and about geometry, arithmetic, and spherics, and, not least, about music; for these studies appear to be sisters.” (Papadopoulos, 2014). A reason for the close relationship between mathematics and music may be that both a mathematician and musician share the ability to extract emotion from their audience as a result of their intimacy with their compositions. The emotion that a piece of music produces is indistinguishable from the emotion that comes from pure mathematical thought. For instance, upon listening to Debussy’s ‘Clair de Lune’ (1905), the soft melody in the right hand accompanied by the gentle chords in the left generates a feeling of warmth and reflection. It is the same emotive force a mathematician feels when they encounter harmony in mathematics.

Iannis Xenakis, a Greek composer and architect, believed in the unison of sound and number. Similar to Morse and Archytas, he wrote “Music, the daughter of number and sound, on an equal basis with the fundamental laws of the human mind and of nature, is naturally the preferred way to express the universe in its fundamental abstraction.” (Xenakis, 1980). This fortifies the notion of the codependency of mathematics and music as well as the relations between a mathematician and an artist. Xenakis proceeds by explaining that “the composer chooses his music because it creates in him [...] an effect that promotes expression of his representation”. Composers such as Bach, Beethoven and Mozart have created their music from an inner passion and love which is then developed into art. Mathematicians share the same type of love and passion for mathematics as the musician does for music, which is then also developed into a beautiful symphony of mathematical propositions.

Johann Sebastian Bach was a German composer of the Baroque period whose style of music is usually described as “mathematical” due to the presence of symmetries and patterns in its structures. His work alone is evidence that the beauty of mathematics and the beauty of music are both complementary, and therefore mathematical and musical thought can be regarded as vastly dependent on one another. Bach’s most notable works are his canons and fugues which possess beautiful mathematical properties. The word “canon” comes from the Greek word “κανών”, meaning “rule”, and it is made up to two voices where one is an exact repetition of the other. The first and second voices are usually referred to by their Italian name “proposta” and “riposta” which loosely translates to “proposal” (question) and “answer”, giving the canon a very symmetrical and orderly quality. Therefore, just as there are rules and laws that musicians need to abide by, there are laws that mathematicians also need to abide by, which is almost suggested by the origin of the word “canon”. Hofstadter begins his ‘Godel, Escher, Bach: An Eternal Golden Braid’ (1979) by explaining what the canon is. He writes that the canon is a “single theme” that is “played against itself” which is done “by having copies of the theme played by the various participants”. A fugue is very similar to a canon, however there are stricter versions of the two voices which “allows for more emotional and artistic expression” (Hofstadter, 1979). Both the structure of the canon and fugue could be described as cyclical or, as Hofstadter describes, endless “strange loops” *(ibid)*. This is very similar to Escher’s illusions in his woodworks and prints that borrow the mathematical notion of infinity. Bach was one of many composers, including modern musicians, who believed in the unison of mathematics and music to create such revolutionary art.

One such musician was Olivier Messiaen, a French composer of the twentieth century, whose work is an example of the idea that “music is a certain way of giving life to mathematical structures, and of rendering them perceptible to our senses [...], music transforms these notions into emotionally affecting objects.” (Papadopoulos, 2014). Perhaps a way that we could understand mathematics is to allow the musician to compose a musical piece that would surrender our senses to beautiful mathematical structures. Key elements of Messiaen’s music are unique rhythmic patterns, repetition and symmetry, inspired by Ancient Greek music, which was used as an accompaniment to poetry recitals and theatre performances. The regular quality of a rhythm can be linked to the regularity of a mathematical sequence, as both are repetitions of a “formula” and the product of ingenious thought. He writes “a rhythmical music which excludes repetition and equal divisions and which finds its inspiration in the movements of nature, which are movements with free and non-equal durations” (Papadopoulos, 2014). Xenakis was a composer of the twentieth century who used modern technology to express his musical capabilities. He speaks highly of technology and says that “today musicians have at their disposal a range of instrumentation, thanks to computers, whose possibilities are incomparably greater than the classical music chamber, [...] ” (Xenakis, 1980). Xenakis had an incredible ear that was able to recognise music in the sounds of nature that the common man would ignore. For example, when he describes his experience in Attica and his visit to the monasteries in Peloponnesus, he exclaims: “I had listened to the sounds of nature and known then, unconsciously, that these sounds had real dignity and constituted music.” *(ibid)*. Similarly, when he participated in a demonstration in Athens he states that “the entire city was filled with cadences” *(ibid)*. In the same way, the mathematician is able to recognise the mathematical characteristics of the natural world. Messiaen and Xenakis are two examples of musicians that have qualities similar to those of the mathematician, and are therefore worthy to be mentioned.

“May not music be described as the mathematics of the sense, mathematics as music of the reason? The musician feels mathematics, the mathematician thinks music: music the dream, mathematics the working life.” - James Joseph Sylvester (Lynch, 2017)

Painters, composers and mathematicians experience the same force that guides their pure thoughts and discoveries, which then combine into beautiful pictures of the universe. These pictures will never stop changing and developing into new and different perspectives or representations of the universe, as seen through the artist’s eyes. The mathematician and the artist go through the same process of piecing together ideas to create a composition. “The mathematician must, like the artist, decide from among the infinities of entities constituting reality which to extract and focus investigation on. Mathematical concepts have to be invented, created, or (perhaps) discovered, much in the same way that Braque and Picasso invented, created, or discovered cubism.” (Jensen, 2002). The rhythms, symmetries and geometric figures in the works of Escher, Dalí, Bach and Messiaen are all foundations to their illustration of the universe, which the audience can appreciate due to the artist’s capability of manipulating their senses. Artists have the ability to convey to their audience the “behind-the-scenes” of the physical world, using paint or sound, and cast a spotlight on beautiful ideas that we perceive to be useful or significant when describing nature. Thus, artists are as close to understanding whatever the “theory of everything” means as mathematicians are. The compositions of a mathematician and artist are created due to the harmony and beauty of their ideas. Morse writes “[...] mathematicians are guided in the discovery and shaping of their theories by their sense of harmony and of beauty.” (Morse, 1950). There is both order and abstraction in the composition of the mathematician and the artist, regardless of their medium or style. Even though mathematics and the creative arts seem to be worlds apart, it is evident that there is mathematics that underlies the creative thinking of an artist, and art and harmony in pure mathematical thought.

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