SYSTEMATIC STRUCTURAL ANALYSIS OF OPTICAL ILLUSION ART AND APPLICATION IN GRAPHIC DESIGN WITH AUTISM SPECTRUM DISORDER

RELATORE : PROF. ARCH. PH.D ANNA MAROTTA
CORRELATORE : ARCH. PH.D ROSSANA NETTI
STUDENT : LI HAORAN

SYSTEMATIC STRUCTURAL ANALYSIS OF OPTICAL ILLUSION ART AND APPLICATION IN GRAPHIC DESIGN WITH AUTISM SPECTRUM DISORDER

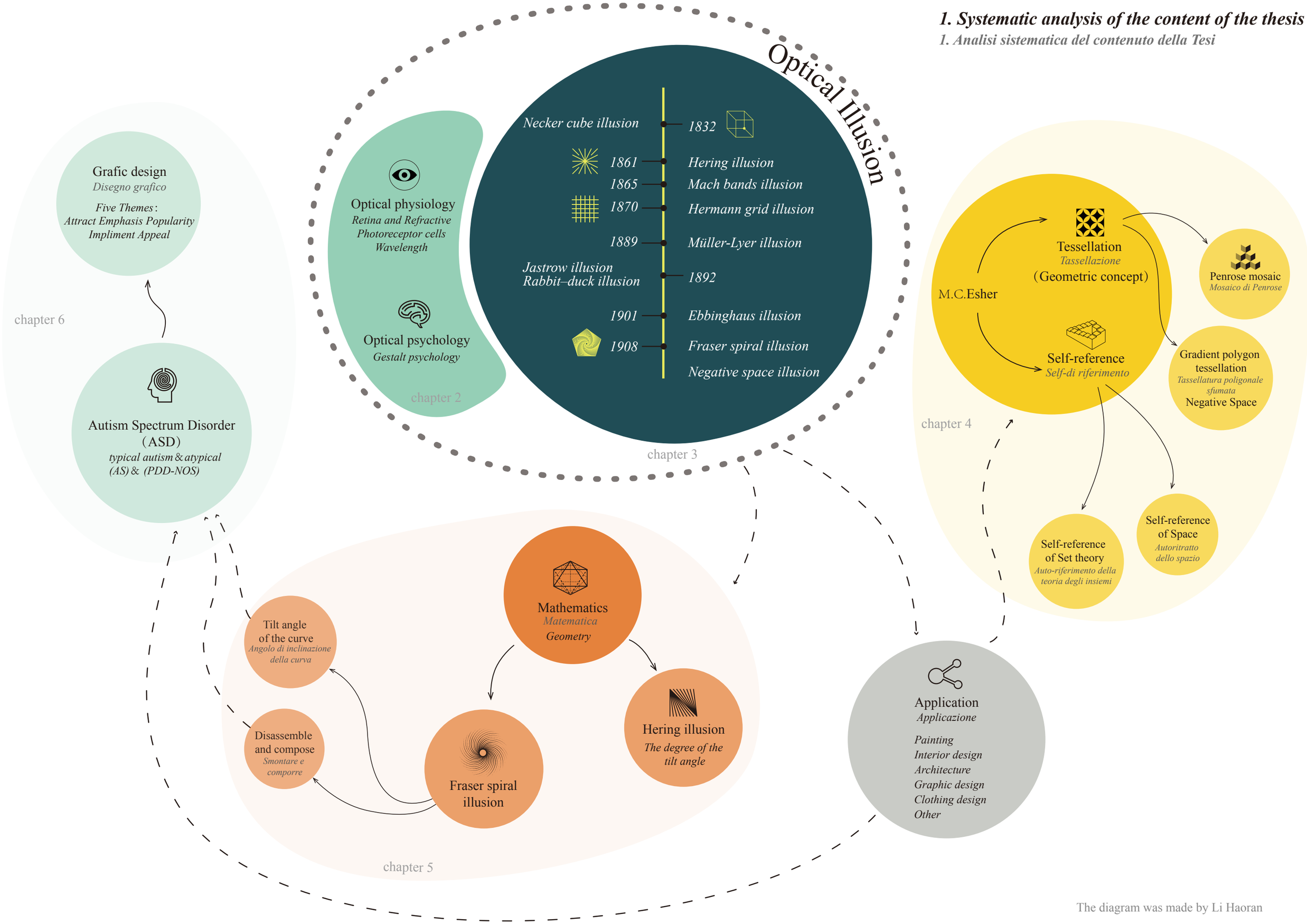
Abstract

To explore the application of optical illusion in different fields, taking M.C. Escher's painting as an example, systematic analysis of optical illusion, Gestalt psychology, and Geometry are performed. Then, from the geometric point of view, to analyze the optical illusion formation model. Taking Fraser Spiral Illusion and Herring Illusion as examples, through the dismantling and combination of Fraser Spiral Illusion and the analysis of the spiral angle, and Herring Illusion tilt angle analysis, the structure of the graph is further explored. This results in a geometric drawing method that optimizes the optical illusion effect and applies this method to graphic design combined with the autism spectrum. Therefore, this project will remind the ordinary people and designers to pay attention to the universal design while also paying attention to extreme people through the combination of graphic design and optical illusion. That is, focus on autism spectrum disorder (ASD), provide more inclusive design and try their best to provide autism spectrum with the deserving autonomy and independence in public space. Meanwhile, making the autism spectrum "integrate" into the general public's environment so that their abilities match the environment and improve self-care capabilities.

Keywords Autism Spectrum Disorder, Inclusive Design, Graphic Design, Gestalt Psychology, Optical Illusion, Systemic Perspective

1. Systematic analysis of the content of the thesis

1. Analisi sistematica del contenuto della Tesi



The diagram was made by Li Haoran

Introduction

People's attention to autism spectrum disorder (ASD) is rarely in public, so there are few public facilities that are specifically built to take into account their characteristics, and there are few obvious signs to remind people to respect their existence and increase their concern for ASD. Thus, I have to do a set of optical illusion graphic design to remind people to pay attention to ASD. The design combines the optical illusion graphical pattern with the main features of the ASD and is divided into five sections to express different themes.

1. *The purpose and significance of the research*

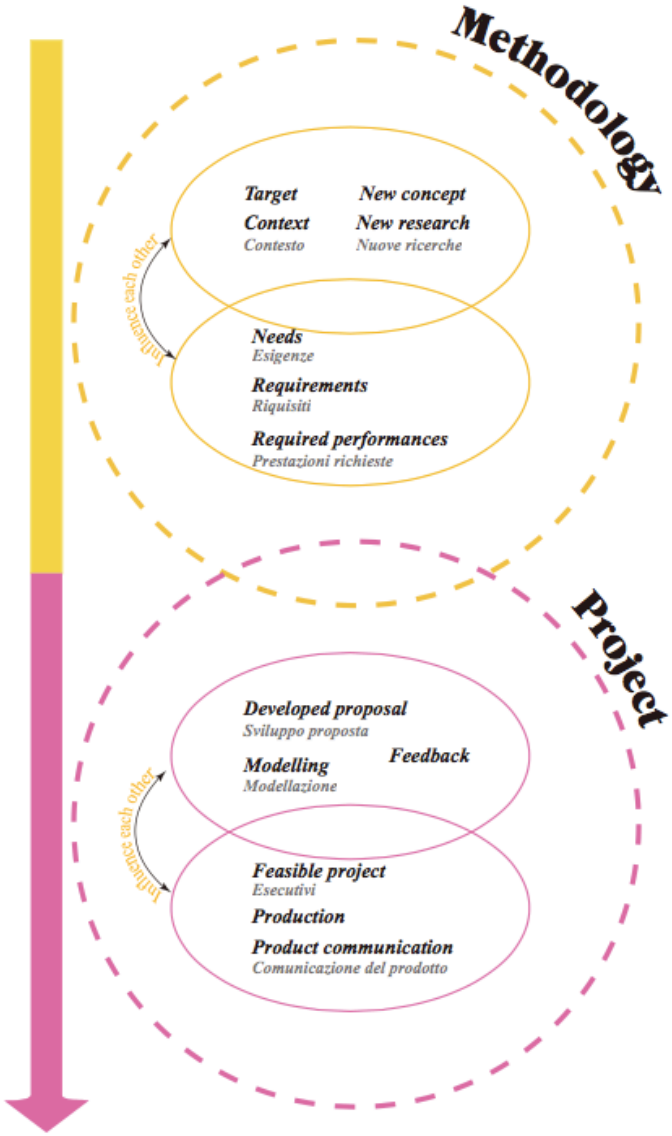
The optical illusion, combined with psychology and physiology, refers to the fact that human vision is affected by physical and psychological factors as well as external physical factors such as light, shape, and color. By exploring the form of optical illusion, it is helpful to further research the essence of the form and content. At the same time, a combination of culture, economics, and ideological background is used to systematically study the optical illusion. This article collates the development history of the optical illusion theory, on this basis, the thinking of optical illusion design is carried out from different perspectives and brings about innovations and breakthroughs in research methods. The study of theories, principles, and techniques that hide the art of optical illusion behind it is introduced into the same system, by designing a variety of optical illusion pictures and carrying out experimental tests, a set of design methodology for making optical illusion art is developed.

Specific research methods, the optical illusion art as a single system containing a set of independent subsystems, multidisciplinary research content covered by the optical illusion of art from a new perspective, to study its main points, requirements and forms of expression. Then find out the project purpose. A system is a set of interacting units with relationships among the Multidisciplinary. and the units have some common properties. they must consist of three kinds of things: elements, interconnections, function or purpose. In the thesis, the optical illusion form is the element; The geometry, mathematics, visual arts, cognitive sciences, gestalt psychology, logic, music, and paintings that interact with each other are interconnections; The purpose is to research the specific methods and formulas of the optical illusion design.

The core analysis principles of systemic view are the same as those of cognitive sciences. That is, first specify the research objectives, then give input and output to represent the conversion system between each other, and finally a reasonable solution is introduced by the system. System design is an interdisciplinary profession. It combines cultural, economic, historical, philosophical and anthropology to explore the research objects and find out the rules from the research objects, so as to find a feasible

design scheme.[1] The entire program is an open system that can communicate with other design products around it and form a sustainable, cross-linked system.[2]

1.1 Methodology with system diagram framework



Explanation： This paper is divided into two parts: methodology and project. Methodology is the theoretical basis and thesis research. Project is the final graphic design.

[1] Annemartine van Kesteren (2017). The transformative power of design. Rotterdam, Museum van

[2] Capra, F., Luisi, P. L. (2014). The systems view of life: a unifying vision. Cambridge, UK: MPG Printgroup Ltd.11.

2. The influencing factor

The visual illusion is caused by psychological factors and physiological factors. This part of the content introduces these two factors, from the background cause to the theoretical analysis.

2.1 *The influencing factor of the optical physiology*

People perceive all things around by perception, such as vision, hearing, smell, taste, touch, etc. Consciousness generally includes people's existing knowledge and experience. At the same time, perception is also related to the conditions and environment when we perceive objects. Because of the difference of the environment, as well as the interference of various factors such as light, form and color, and other physiological reasons, people often make mistakes in the perception of objects. This is the illusion. Since more than eighty percent of the information we collect is visually acquired, vision is the most important perception system that humans and animals communicate with the world. Visual physiological term refers to the light through the visual organ, this is the eye, so that the cells excited, the signal and then processed by the visual nerve coding and analysis of a subjective experience.

Before people can understand the working principle of the eye without scientifically, how the eye works, the Chinese and the Western countries have discussed mainly whether the object enters the eye, or the eye emits its own light, and the object returns to produce the vision. As early as four hundred or five hundred years BC, Greek Pythagoras and other scholars believe that the object of observation will emit particles into the pupil of the eye, resulting in vision. The Platonic scholars, on the other hand, think that the eye itself shines, thinking that something emitted by the eye encounters the object and produces vision. In the same period of ancient China, the mainstream view was also that the eyes were the receivers of the external objects.[3]

In modern times, science has confirmed that the eye is one of the most important sensory organs in vision, including the retina and refractive (corneal, lens, vitreous) parts of photoreceptor cells (rods and cones). Wavelengths in the 370-740 nm electromagnetic wave is the most appropriate, will produce stimulation, that is, the visible part of up to 150 colors. The light of this part needs to be imaged first on the retina through the refractive system, and then passes through the optic nerve and reacts to the visual center of the brain, thereby discerning the light and shade of the object seen. Finally see the visual range of luminous or reflective objects shape, size, color, distance and surface details and other information. Human perception has selectivity, and it will perceive the material world. When the molecular movement of the material world does not meet the needs of the perception subject, perception does not produce any action. When the perceiving subject finds the image that suits his own needs, it

[3] Gregory R L, (1978) Eyes and Brain: The Psychology of Seeing 3rd edition (New York: McGraw-Hill)

will screen the image to stimulate the senses and make the body move. The French philosopher Henri Bergson calls this perception behavior consciousness.

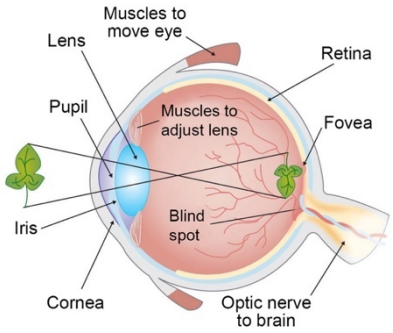


Figure 1. Optic nerve system

https://askabiologist.asu.edu/rods-and-cones (access in February 2018)

2.2 The influencing factor of the optical psychology

The German psychologist Hermann Ebbinghaus (1850-1909), he said that psychology has a long process, but only a short history. The modern psychology was born in 1897 and it was only 100 years old. The psychology of seeing, as one of the subdivisions of psychology, is also beginning in modern times. The psychology of seeing is the study to find a special relationship between visual and thinking not the common relationship. This opinion distinguished from visual aesthetics. The psychology of seeing refers to the psychological mechanism reaction caused by the external image through the visual organs.[4]

Psychology, as an interdisciplinary of natural science and social science, develops with the step of Natural Science. The foundation of the psychology of seeing should begin with the fact that physiology became an independent science in the 1830s and scientists' achievements in sensory physiology and neurophysiology are essential for the development of Psychology.

Psychologists in this laboratory used experimental methods to study the regulars of psychology and behavior. The laboratory marks the birth of modern scientific psychology. In his work 'Principles of Physiological Psychology', it is the first time systematically introduces the history, design and method of the generation and development of experimental instruments in psychology.[5] By the influence on experimental psychology, in 1960 Sir Ernst Hans Josef Gombrich (1909-2001) put forward the opinion in the psychology of perception: Pictorial representation in his book 'Art and Illusion'.[6]

---

[4] Arnheim R, (2004) Art and Visual Perception: A Psychology of the Creative Eye. Berkeley: University of California Press

[5] Marr, D.(1982). Vision: A Computational Investigation into the Human Representation and Processing of Visual Information. W. H. Freeman.

[6] Schiano D J, (1986) "Relative size and spatial separation: effects on the parallel-lines illusion" Perception and Motor Skills 63 1151–1155

In 1912 three lectures: Max Wertheimer, Wolfgang Köhler and Kurt Koffka in Goethe University Frankfurt founded the laboratory and Gestalt school. The Gestalt psychology is linked closely with the art. Gestalt psychologists believe that there are some images in the brain and these images are the brain electric field that copies the shape of the perceived object. They also think that the whole is not a simple addition and the whole is determined by its internal structure and property. This opinion explains that the inspiration of art is not isolated but is related closely to the observation in daily life. The 'observation' means the interaction of natural object and observer object. Rudolf Arnheim (1904-2007) founded the Gestalt psychology aesthetics based on the Gestalt psychology. He believed that 'perception' is the foundation of artistic thinking and the structure of artistic representation lies in the structure of 'strength'. This idea was recorded in his work 'Art and Visual Perception: A Psychology of the Creative Eye'.[7]

Overall, psychologists find the source of flowing artistic inspiration from the insipid data. They summarized the experience and experimental results from simple visual imaging to complex psychological perception and then people's understanding of beauty is perfected.

3.The classification of optical illusion

Based on the intrinsic link between the forms of visual illusion and the different forms of expression in cognitive science, this article will focus on explaining the following ten kinds of visual illusions after comprehensively reviewing data on various factors. The purpose is to explore new design methods through the inherent laws between each other and apply them to universal and extreme populations. Extreme refers to patients with autism. This article aims to design general guidelines for normal people and autistic patients.[8]

3.1 Basic information interpretation of Müller-Lyer illusion and analysis of related application fields

Müller-Lyer illusion was designed by Franz Carl Müller-Lyer in 1889.[9] Muller Lyer Illusion is a visual illusion involving an arrow in which the direction of the arrow makes a line look longer than the other, as shown in the figure, we see the length of the left longer than the right, although the length of both lines are exactly the same.[10] On the illusion of Müller-Lyer, one obvious question is why these additional lines will affect

[7] Bulatov A, Bertulis A, Mickiene L, (1997) "Geometrical illusions: study and modelling" Biological Cybernetics 77 395–406

[8] Chiang C A, (1968) "A new theory to explain geometrical illusions by crossing lines" Perception & Psychophysics 3 174–176

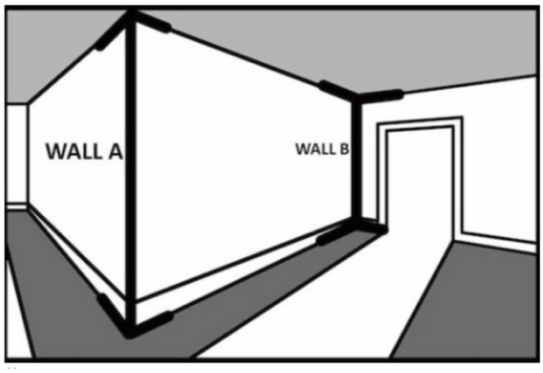
[9] Davies T N, Spencer J, (1977) "An explanation for the Müller-Lyer illusion" Perception and Motor Skills 45 219–224

[10] Dewar R E, (1967) "Stimulus determinations of the magnitude of the Müller-Lyer illusion" Perception and Motor Skills 24 708–710

our view of length? Most of the explanations of the Müller-Lyer illusion focus on the relationship between size and depth.[11] For people, the angle of inward orientation is usually considered to be closer. Thus, from the point of view of the people, these lines are "actually" shorter, although they are of the same length.

Müller-Lyer illusion can be applied in many different ways, even if some small tips will be very different. For example, we can achieve the effect we want to achieve by slightly changing the angle of the arrow. In addition, we think that the image, to some extent, is only composed of our brain cognitive. Therefore, we can use these illusion techniques, some non-existent information, in a credible way to convey to the audience. We can see in the architect's design drawings that they use outward and inward arrows to present different lines of distance. We can see that in the following figure, two lines are drawn to create a sense of a three-dimensional space.

2



3

Figure 2 The direction of the arrow makes a line look longer than the other.
http://ideate.xsead.cmu.edu/gallery/projects/muller-lyer- illution (access in February 2018)

Figure 3 In the architect's design drawings that they use outward and inward arrows to present different lines of distance.
http://ideate.xsead.cmu.edu/gallery/projects/muller-lyer- illution (access in February 2018)

3.2 Basic information interpretation of Hering illusion and analysis of related application fields

The Hering illusion is also called ‘Divergence line illusion’. The Hering illusion is the distortion of the simple cells in the primary visual cortex in space, which is caused by the time delay in the visual system. It was discovered by the German physiologist Ewald Hering in 1861.[12] The two parallel lines are curved due to the oblique line. The two lines seem to be curved, however, in fact, they are parallel. If you moved these red lines out of the centre of screen, the illusion effect would be decreased. Therefore, we

[11] Erlebacher A, Sekuler R, (1974) “Perceived length depends on exposure duration: Straight lines and Müller-Lyer stimuli” Journal of Experimental Psychology 103 724–728

[12] Tagliasco V, Vincenzi A, Boringhieri B, (1998) Dietro le formule: I discorsi della logica e della matematica (Comunicazione e linguaggio). Milan

observe this kind of illusion and two red lines in the background must be less than 90 degrees oblique angle.

This illusion just happens when the image is horizontal or vertical. If we rotate the parallel line to another angle, the illusion would not happen. The effect of Hering illusion is connected by the position of angle. We can feel the distortion because of oblique lines behind parallel lines.[13] In other word, owing to simulate the effect of lining pattern on the background caused this effect: parallel lines are fastigiated, and it produces a deep wrong impression. The illusion has another keynote is the central point. In fact, all the lines intersect at one point, like the spokes of a bicycle. So, it brings us an impression that we move straightly. We recognize that lines are bend as we are standing. *(Fig.4)* Twisted cube. The cube seems twisted, but it is square, actually. *(Fig.5)* Another variant of the square that combines the illusions of Herning, and actually, lines are also straight. *(Fig.6) (Fig.7) (Fig.8)* They are the evolution of Hering's optical illusion in art, which applies the character of the Hering illusion in fashion, interior design, installation art ecc.in a flexible way.

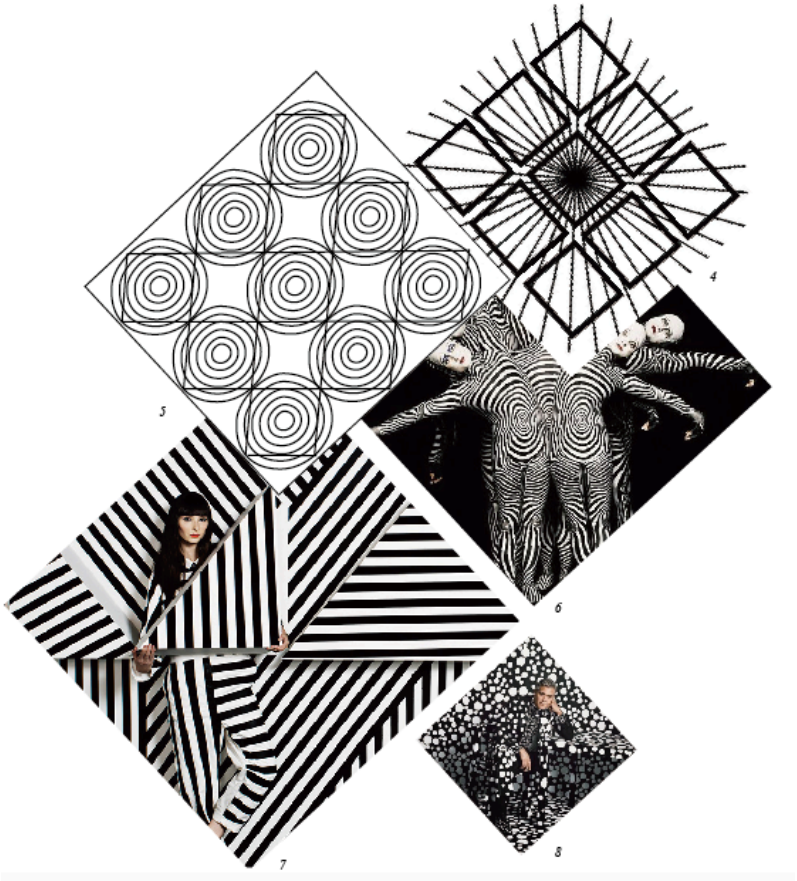


Figure 4. Twisted cube. The cube seems twisted, but it is square, actually.
https://www.weirdoptics.com/distorted-squares-visual-optical-illusion/(access in February 2018)

Figure 5. Another variant of the square that combines the illusions of Hering, and actually, lines are also straight.
http://www.michaelbach.de/ot/ang-hering/(access in February 2018)

Figure 6. Figure 7. Figure 8. They are the evolution of Hering's optical illusion in art,

[13] Williams, Robert. (1979) The Geometrical Foundation of Natural Structure: A Source Book of Design. Dover Publications.

http://erikaschiquis.blogspot.it/2013/03/cirque-du-soleil-costumes.html(access in February 2018)
http://www.stylemode.com/life/artstyle/2015-08-28/pic2667.html(access in February 2018)
http://www.ideamsg.com/2017/03/yayoi-kusama/ (access in February 2018)

3.3 Basic information interpretation of Hermann grid illusion and analysis of related application fields

The Hermann grid illusion is an optical illusion described by Ludimar Hermann in 1870, when viewing the Herman grid, you may notice a faint black spot that appears at the intersection of white lines. But why does it appear? Once you look directly at them, why do they disappear?

This takes into account the two regions of the retina, one area observing the intersection of the white and vertical bands, and the other area viewing the white band between the two intersections (the area away from the intersection). Although the two sides of their own light the same, but the situation is not the same in neighboring areas. At the crossroads, there was light on all sides, but in the white stripes between the two crossroads, it was surrounded by two dark sides.[14]

This is called the physiological mechanism of lateral inhibition, because the bright surround makes the area look darker, on the contrary, the dark surround will make the area look brighter. *(Fig.9)* Horizontal suppression also explains the illusion produced by the above comparison. The center of the two squares is the same color, but due to the simultaneous contrast effect, the dark surround will make the area look brighter. So, they do not look the same.

Many magicians use the same principle of contrast to hide the parts of their magic devices. For example, maybe they want to hide the support of the floating parts. The magician will make the surrounding area particularly bright, for example with shiny metal objects, white close and so on. *(Fig.10) (Fig.11)* are decorative design products made using Herman Grid illusion. When viewing the picture, there are dark spots on the white intersection, and as long as the center of the line of sight is shifted there, the "dark spots" disappear.

[14] Restle F, (1971) “Visual illusions”, in Adaptation Level Theory Ed. Appley M H (New York: Academic Press)

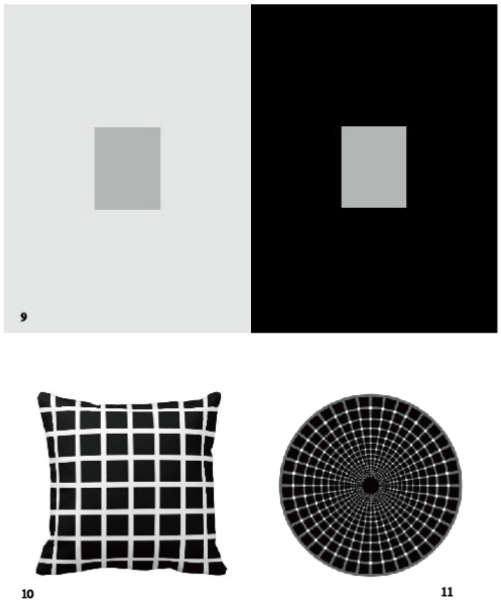


Figure 9. By contrast, the dark surround will make the area look brighter.
http://www.shicuojue.com/article-253-1.html (access in February 2018)

Figure 10. Pillow be made with Herman grid illusion.
https://it.pinterest.com/pin/703756175130747/ (access in February 2018)

Figure 11. Hidden black dots have different hues because the bright surrounds make the hidden black dots look brighter.
http://www.aboluowang.com/2016/0318/709848. html (access in February 2018)

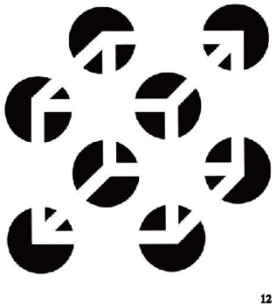
3.4 Basic information interpretation of Necker cube illusion and analysis of related application fields

The Necker Cube is an optical illusion that is a 3D wireframe cube represented by 2D. The Necker cube was first described by the Swiss crystallographer Louis Albert Necker in 1832, and he observed that ambiguous shapes could spontaneously convert perspective, such as *(Fig.12) (Fig.13)* In the same possible view of the object being represented. Such graphics are called unclear graphics, such as impossible number, impossible cube, penrose triangle, and so on. The Necker cube reveals the human visual system. This phenomenon has become evidence of the human brain as a neural network with two distinct interchangeable states, such as Sidney Bradford, a blind person under the age of ten, but at the age of 52 restored his eyesight, he did not notice the ambiguity of the Necker cube.

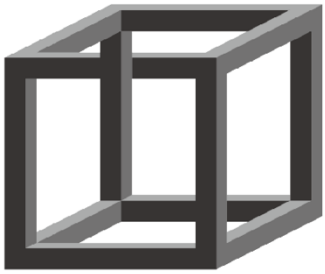
M.C. Escher [15] have a lot of twisted perspective, is polyhedron, visual pun, and visual paradox. Escher is through the infinite exploration, in two or three dimensions, and

[15] Maurits Cornelis Escher (1898-1972) was a Dutch graphic artist who made mathematically-inspired woodcuts, lithographs, and mezzotints .

contradictory space for us express that impossible structure, which is different from what we usually see the pattern.



12



13

Figure 12. The Necker cube is called unclear graphics, it draws a cube in the perspective of an isometric perspective.
http://locoquevuela.blogspot.it/2014/02/leyes- the brain tends to think of this cube as looking down from above. de-la-percepcion-visual-gestalt.html (access in February 2018)

Figure 13. The picture does not indicate whether the cube is up or down, when people look at it, you can find it can change direction.
https://en.wikipedia.org/wiki/Necker_cube (access in February 2018)

3.5 Basic information interpretation of Ebbinghaus illusion and analysis of related application fields

The Ebbinghaus illusion is an illusion about the size perception and it is also called Titchener circles. The Ebbinghaus illusion is named by the German psychologist Hermann Ebbinghaus (1850-1909).[16] *(Fig.14)* There are two orange point with the same size in the central, as one is surrounded by a large circle and the other is surrounded by a small circle, which shows a larger one on the right in vision. There is a lot of controversy about the causes of the Ebbinghaus illusion. In general, it is believed that this illusion is related to behavior and perception. Neuroimaging researched that the sensitive about this illusion is linked with context-sensitivity. Research shows that adults are more sensitive to the background, so they are less likely to be defrauded by the background circle than children.[17]

The same as the Ebbinghaus illusion, put two points with the same size, one of them surrounded by a larger circle.[18] (*Fig.15*) The point surrounded by a larger circle looks like bigger than the other one. This illusion called the Delboeuf illusion. This illusion could explain why people more like using big plate to put food. (*Fig.16*) However, in

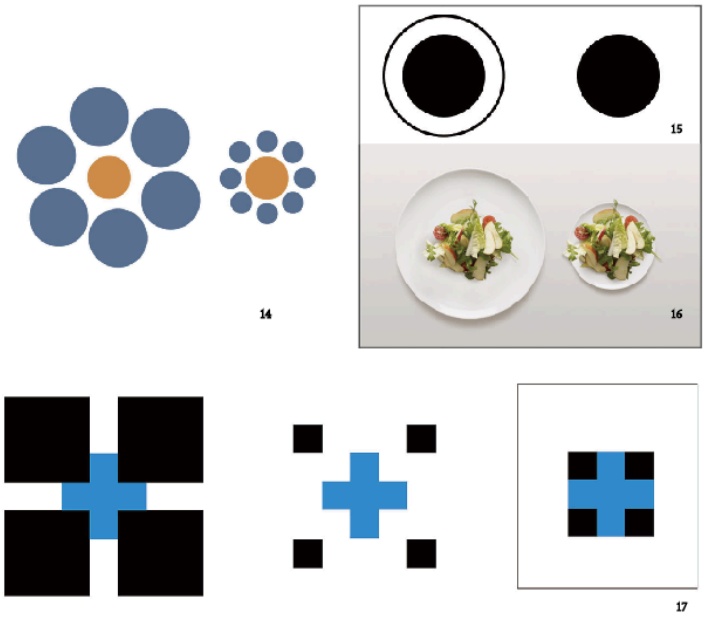
[16] Roberts B, Harris M G, Yates T A, (2005) "The roles of inducer size and distance in the Ebbinghaus illusion (Titchener circles)" Perception 34 847–856

[17] Massaro D W, Anderson N H, (1971) "Judgmental model of the Ebbinghaus illusion" Journal of Experimental Psychology 89 147–151

[18] Jaeger T, Grasso K, (1993) "Contour lightness and separation effects in the Ebbinghaus illusion" Perception and Motor Skills 76 255–258

2013, Italian visual researcher Gianni A. Sarcone discovered a new relative size illusion opposite to the Ebbinghaus illusion. It is called Sarcone's Crosses *(Fig.17)* Three blue crosses are the same size and the blue cross surrounded by the big square, looks bigger. This also indicates that the size of the surrounding shape is not always related to the size of the test shape.[19]

Figure 14. The original picture of Ebbinghaus illusion. Two orange circles are the same size but the right one is bigger.



http://www.elsalvador.com/vida/ 186208/ increibles-ilusiones-opticas-que-juegan-con-tu-cerebro/ (access in February 2018)

Figure 15. The picture of Delboeuf illusion. The point surrounded by a larger circle looks like bigger. https://en.wikipedia.org/wiki/Delboeuf_illusion (access in February 2018)

Figure 16. The picture explains why people more like using big plate to put food. http://www.esports tness.org/eating-life-hacks/ (access in February 2018)

Figure 17. The Sarcone's Crosses is the picture to refute the Ebbinghaus illusion. https://en.wikipedia.org/wiki/Ebbinghaus_ illusion (access in February 2018)

3.6 Basic information interpretation of Fraser spiral illusion and analysis of related application fields

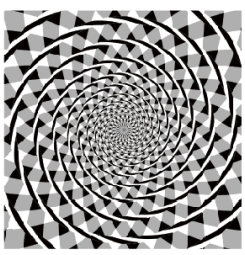
The Fraser spiral illusion is an optical illusion that was first described by the British psychologist Sir James Fraser (1863 – 1936) in 1908.[20] When observer looking at the Fraser spiral, there seems to be a twisted spiral constructed by black curves. In fact, the "spiral" is a series of concentric circles. James Fraser overlaps a set of concentric circles and a specific background that created a spiral visual effect. Visual distortion is

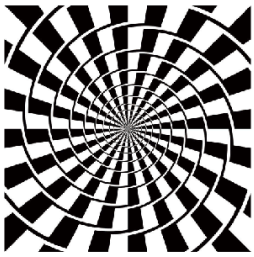
[19] Girgus J S, Coren S, Agdern M, (1972) "The interrelationship between the Ebbinghaus and Delbœuf illusions" Journal of Experimental Psychology 95 453–455

[20] Fraser J (1908) A New Visual Illusion of Direction. British Journal of Psychology 2:307–320

caused by combined regular linear patterns (circles as outline) with staggered short curves (black & white). This effect is enhanced by the spiral tessellation background. Like other kinds of visual illusions, twisted spirals are caused by the illusion of deviations of visual nerve, which produced by the staggered curve elements in concentric circles. As shown in (*Fig.18*) (*Fig.19*)

The visual principle of the café illusion is the same as the Fraser spiral illusion, the café wall illusion was first described under the name Kindergarten illusion in 1898,[21] and re-discovered in 1973 by Richard Gregory.[22] This illusion is caused by the deviation of light and dark tiles surrounded by "grout lines", and the illusion strength is affected by the location of the tiles and the thickness and color of the grout line between them. If the grout line is removed, there is no longer any illusion of the lines. (*Fig.20*)


18


19

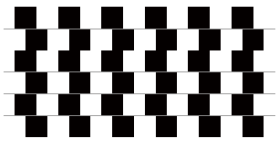

20

Figure 18. Fraser spiral, the "spiral" is a series of concentric circles.
https://soundcloud.com/richard-klein-tekno/the-dark-groove-of-black-magic(access in March 2018)

Figure 19. Fraser spiral, visual distortion is caused by combined regular linear patterns (circles as outline) with staggered short curves (black & white).
https://www.pinterest.es/pin/447967494157280617/?lp=true(access in March 2018)

Figure 20. Café wall illusion, the deviation of visual nerve is caused by the location of the tiles and the thickness of the grout line.
http://smart-kit.com/s758/cafe-wall-illusion/(access in March 2018)

3.7 Basic information interpretation of Negative space illusion and analysis of related application fields

The negative space in the art is the space between the main body of an image. The negative space is probably the most obvious when the space surrounds the subject rather than the subject itself to form interesting or artistic-related shapes, and this space is occasionally used as an artistic effect as the "real" subject of the image. Negative space, sometimes called a blank space, is a concept that has been used for hundreds of years

[21] Pierce, A.H. (1898). "The illusions of the kindergarten patterns". Psychological Review. 5 (3): 233–53.

[22] Gregory, R.L.; Heard, P. (1979). "Border locking and the Café Wall illusion" (PDF). Perception. 8 (4): 365–80.

in art, design, architecture and sculpture.[23] Negative space defines and emphasizes the subject of the picture, attracting eyeballs. It offers "breathing room" that keeps your eyes in a place to rest and prevent your images from looking too messy. Help to create more attractive works. Negative space art, try to tell stories through art and space. As an art form, it is fascinating and powerful. The musician describes the silence in the musical works as a negative space. In the graphic design, the use of negative space is essential for effective communication. Use negative spaces to more efficiently view shapes and sizes and generate better combined images. Advertising is more common, such as trademark logo and so on.

Negative space is, quite simply, the space that surrounds an object in an image. Just as important as that object itself, negative space helps to de ne the boundaries of positive space and brings balance to a composition.

More and more these days, the creative world is seeing an emergence of artists creating positive spaces and shapes that, in turn, cleverly carve out shapes in negative space, and the results can be stunning. Here, we have found some brilliant examples，the negative space is used in the art of graphic design. (Fig.21) (Fig.22) (Fig.23) (Fig.24)

Figure 21. Tang Yau Hoong, “DAY VS. NIGHT” ，2017，Use of negative space reflects the relativity of day and night.

Figure 22. Tang Yau Hoong , “THE PHILOSOPHER”，2017，Use of negative space combine the philosopher with question mark .

Figure 23. Tang Yau Hoong , “I’M LOVIN IT”，2017，Combine McDonald's with diners.

Figure 24. Tang Yau Hoong , “TOMORROW’S EDUCATION”，2017，Use of negative space to describe pencils and ladder to reflect future education of different ages.
http://www.enkil.org/2017/01/17/tang-yau-hoong- negative-space/ (access in March 2018)

[23] Goto T, Uchiyama I, Imai A, Takahashi S, Hanari T, Nakamura S, Kobari H, (2007) “Assimilation and contrast in optical illusions” Japanese Psychological Research 49 33–44

3.8 Basic information interpretation of Jastrow illusion and analysis of related application fields

The Jastrow Illusion is an optical illusion discovered by the American psychologist Joseph Jastrow in 1889. The illusion has four names: Ring-Segment illusion, Jastrow illusion, Wundt area illusion or Wundt-Jastrow illusion. From the (*Fig.25*). we can nd that two pieces of fan-shaped plates with exactly the same size are placed together, and we can clearly feel that the fan piece below seems to be larger. The reason why this illusion hap- pens has three arguments. One of the most acceptable explanations is that the brain is confused to recognize the size of large radius and small radius, so they believe that the fan- piece below is bigger. In (*Fig.26*). there are three cats with similar size and we feel like the cat on the top is smaller.[24]

The Japanese psychologist Shogu Imai in 1960 tested different vision of Wundt-Jastrow illusion.[25] He found that when the inner radius is 60% of the outer radius, the perceptual perception is the largest and when the distance between the two lines is removed, the degree of hallucination decreases.[26] Other scientists through the research found that in other shapes such as trapezium, parallelogram and so on, there is similar illusion effect.[27] In (*Fig.27*). there are two coffee cups of the same size stacked together. In general people would choose the one below because it looks bigger. The Jastrow Illusion was applied to the decoration of architecture and a kind of magic toy.

25 26 27

Figure 25. It is a magic toy which is applied to the Jastrow Illusion.
https://magicperspectives.net/wp-content/ uploads/sites/3/2016/08/jastrow_ebook.jpg (access in March 2018)

Figure 26. & Figure 27. The case to explain the Jastrow Illusion is applied to the graphic design and three-dimensional graphics.
http://ideate.xsead.cmu.edu/gallery/projects/ penrose-triangle (access in March 2018)

[24] Judd C H, (1902) "Practice and its effects on the geometric illusions" Psychological Review 9 27–39

[25] Pressey A W, Murray R, (1976) "Further developments in the assimilation theory of geometrical illusions: the adjacency principle" Perception & Psychophysics 19 536–544

[26] Restle F, Merryman C, (1969) "Distance and an illusion of length of line" Journal of Experimental Psychology 81 297– 302

[27] Goto T, (1992) "Functional representation of visual illusions by use of various stimulus-presenting conditions" International Journal of Psychology 27 31–32

3.9 Basic information interpretation of Mach bands illusion and analysis of related application fields

Mach band is a brightness contrast phenomenon, which was discovered by the Austrain physicist Ernst Mach in 1868. It is a subjective edge contrast effect. When the brightness of tow part is different, the contrast of the edge is enhanced, and the contour is particularly obvious.[28] We explain the Mach band effect by lateral inhibition. The lateral inhibition means reciprocal inhibition between adjacent receptors. The process happens on the retain, therefore the inhibition is stronger in brighter part than the dark part.

Now the Mach band effect is applied to the medical treatment such as the diagnosis of enamel with X-ray and cataclasis.

3.10 Basic information interpretation of Rabbit–duck illusion and analysis of related application fields

The earliest vision of 'rabbit–duck illusion' is on a German magazine called 'Fliegende Blatter' (23/10/1892 P147). We called these images Ambiguous images or reversible figures. Different people has different comprehension: somebody thinks that the image indicated a duke, while others believes that it is a rabbit. There are two reasons to understand it: the first reason is the 'middle vision'. The middle vision is responsible for classification of graphic objects and this step is before the 'recognize the scene'. For instance, (*Fig.28*). we understand that it is an animal first, then we classify which kind of animal it is. The perception of the image comes from the edge by the middle vision and the perception of the contour is used to distinguish the background and the image. The illusion comes from the different understanding of the fuzzy consciousness of the edge. So, someone sees the rabbit first and the other one sees the duck.[29]

The second is the difference between the thinking. This is the category of Philosophy. The German philosopher Ludwig Josef Johann Wittgenstein wrote a book called 'Philosophical Investigations' in 1953, which described this optical illusion in detail: 'But since it is the description of a perception, it can also be called the expression of thought. If you are looking at the object, you need not think of it; but if you are having the visual experience expressed by the exclamation, you are also thinking of what you see.' 'Hence the flashing of an aspect on us seems half visual experience, half thought.'

The perception of images is an expression of ideas. Different people think differently from one object, and the description of objects is different. From this point of view, we can see: (*Fig.29*). using the theory of the middle vision, in the picture, the round edge is classified as 'eyes',

---

[28] Restle F, (1977) "Assimilation produced by contrast", in Cognitive Theory volume 3, Eds Castellan N J, Restle F (Hillsdale, NJ: Lawrence Erlbaum Associates)

[29] Hamburger K, Hasen T, Gegenfurtner K R, (2007) "Geometric-optical illusions at isoluminance" Vision Research 47 3276–3285

While others are divided into ‘nostrils’. (*Fig.30*). The former perception of the figure is as ‘frog’ and the other is understood as ‘horse’. From the thinking point of view, some people think of the background as water, while others understand it is grassland. It is understood that the water edge makes the figure into a frog, and the background ‘grassland’ is the ‘horse’ the same as Pic.4 ‘girl and the old woman’. This optical illusion is now used to graphic design. (*Fig.31*). This optical illusion ascends the interest of visual art.

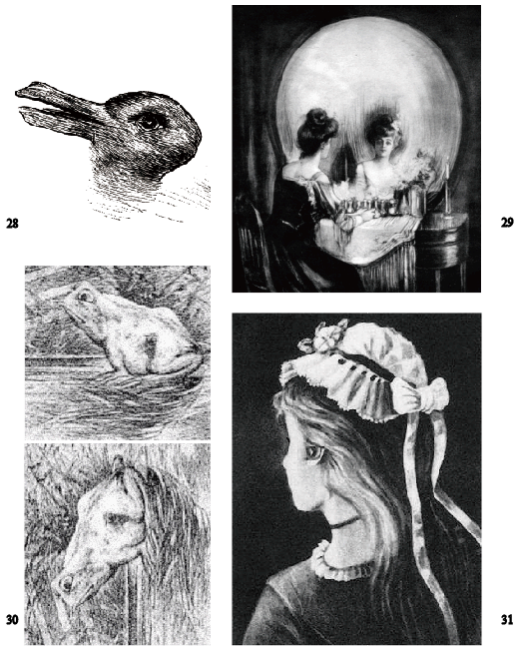


Figure 28. The picture of the Ruck-rabbit illusion. The first look is a duck or a rabbit.
http://www.independent.co.uk/news/- science/duck-or-rabbit-the-100-year-old-optical -illusion-that-tells-you-how-creative-you-are-a6 873106. html (access in March 2018)

Figure 29. The application of the Ruck-rabbit illusion. The first look is a girl who looks into a mirror or a human skeleton.
http://i.imgur.com/IcIYCSo.jpg (access in March 2018)

Figure 30. The case of the Ruck-rabbit illusion. It is a frog or a horse by flipping the picture.
http://depo.ba/media/pic- tures/2015/03/11/ thumbs/55006623-9d80-4c91-8 5d1-11e8d973813c- zaba-konj-opticka-iluzija-pre viewOrg.jpg (access in March 2018)

Figure 31. The application of the Ruck-rabbit illusion. The first look is a girl or an old woman.
https://4.bp.blogspot.com/-t_TrS 9RW3Ho/ U_yXvQ7aAiI/AAAAAAAAD9Y/b1scN R0RCfU/ s1600/young-girl-or-old-woman-am- biguous-optical- illusion.jpg (access in March 2018)

4. Using systemic theory to analyze the relation between M.C. Escher's two main pattern of works (Spatial self-reference and Tessellation) and Necker cube illusion, Negative illusion, and Fraser spiral illusion

The 20th-century legendary figure in the history of art, Maurits Cornelis Escher (1898- 1972). While various disciplines flourished in the social and historical context, he combined and explored various mathematical concepts and even logical problems in his works. To visualize these seldom involved abstract concepts, achieved the unique artistic charm of Escher. In the fields of plane composition, shape gradient, geometry combination, and optical illusion (impossible graphics), Escher's status could be unprecedented, and each of his prints is a thought-provoking mysterious world. Now I will contact the Necker cube illusion, Negative illusion, Fraser spiral illusion and the two painting elements in Escher's work, that is to analyze "self-reference" and "Tessellation".

"Self-reference" is usually a linguistic or logical concept, which is a sentence describing the sentence itself. This circular, recursive statement can often create an intriguing realm. The exploration of "self- reference" is an important type in Escher's work, where his work is divided into two parts, namely "self-reference of Space" and "self-reference of Set theory". The impossibility of the Penrose stairs and Penrose triangles proposed by the mathematician Roger Penrose in 1958, this is a well-known geometric paradox. It refers to a motion pattern that always loops up and down indefinitely, it is the main source of inspiration for Escher's "spatial self-reference" work. Of course, Penrose stairs and Penrose triangles and Necker cube illusion are both spatial self-reference, and they have the same principle of visual cognition, that is, when visual signals are well-interpreted in several different scenarios, the human visual center becomes confused between several steady states, there seems to be some kind of movement. For example, if we stare at a cubic wireframe that does not have a perspective, we will feel that it is front for a while, and think it is back for a while. The Penrose stairs and Penrose triangles and Necker cube illusion are often used in artistic designs, as shown in (*Fig.35*). (*Fig.36*). (*Fig.37*).

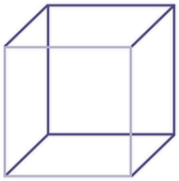


Figure 35

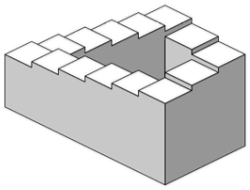


Figure 36

Figure 37

Figure 35. Necker cube illusion

http://www.illusionsindex.org/i/grey-strawberries (access in March 2018)

Figure 36. The Penrose stairs

4.1 Logical thinking diagram to express all the contents of this part

4.1 Diagramma di pensiero logico per esprimere tutto il contenuto di questa parte

M.C.Esher

Negative Space
Gestalt Psychology
Sky and Water
Day and Night
periodic mosaic/ deformation/ symmetry

Penrose mosaic
Mosaico di Penrose
mosaic collages of Islamic architecture

Gradient polygon tessellation
Tassellatura poligonale sfumata

Tessellation
Tassellazione
(Geometric concept)

Self-reference
Self-di riferimento

Hyperbolic paraboloid tessellation
Paraboloide iperbolico tassellazione

Alhambra Palace/
Intricate mosaics/
Tile collages/
Persian interwoven patterns

Advanced astronomy & Geometry
Astronomia e geometria avanzata

Self-reference of Set theory
Auto-riferimento della teoria degli insiemi

Self-reference of Space
Autoritratto dello spazio

Acoustic
Acustico

Visual
Visivo

Waterfall
Ascending and Descending
Cognitive Sciences
Necker Cube illusion

Circle limit series
central expansion/ marginak diminishing effect/ fractal pattern

Lizard
Bird and Fish
Decorative pattern with order and rhythm

M.C.Esher
Dragon
Ouroboros
Ancient symbol of the world
Antico simbolo del mondo

‘Canon’method of composing music
‘Brother John’
space and time construction

J.S.Bach
Reprensentation of Baroque music
‘Crab Canon’

Shepard Tones
endless rise or fall
eg. rotating drum of barber

Hans Zimmer
musician

Necker Cube
Gestalt Psychology
multistable perception
percezione multistabile

China
Jade dragon

Egypt
New Emoire Period of Egypt on the gold-plated coffin of Tutankhamun

Hands
Self-reference
Self-di riferimento

Mobius StripII Red Ants
Esher

Circle limit IV
Octagonal 6th-order square mosaic
Mosaico quadrato ottagonale del sesto ordine

Circle limit III
Alternated octagonal tiling
Piastrellatura ottagonale alternata

Russel’s Paradox
Il paradosso di Russel

Cognitive Sciences
Scienze cognitive

Geometry
Geometria

Gallery
Recursive structure
Fraser illusion &
Geometric deformation
Struttura ricorsiva
Fraser illusion &
deformazione geometrica

Orange: M.C.Escher’s works

The diagram was made by Li Haoran

http://lewebpedagogique.com/claudegirardchatillonleduc/ les/2012/06/escalier2.png (access in March 2018)

Figure 37. The LOGO of Centre for the Study of Perceptual Experience, the design combines the Necker cube illusion with the Penrose stairs.

http://www.illusionsindex.org/i/grey-strawberries (access in March 2018)

4.2 The relation between the spatial self-reference (painting and music) and Necker Cube illusion

The painting Ascending and Descending M.C. Escher's, which actually very highest level? Which sink is the lowest in this Waterfall? Everywhere like this is higher than the previous one, but it eventually returns to the lowest point, of course, it does not exist in the three-dimensional space. But this does not prevent us from conceiving that Escher's inspiration from the Penrose stairs and Necker cube illusion. M.C. Escher with a wonderful paradox and illusion to show ordinary people cannot understand a contradiction space. The strangely shaped staircases in his paintings, the bizarre geometric lines are an endless process, this starting point is the endpoint, and the endpoint is the starting point' s the eternal cycle that hides the profound meaning of modern mathematics and philosophy.

Figure 38

Figure 39

Figure 38.

M.C. Escher, Ascending and Descending ,1960, Lithograph. 285mm x 355mm.

http://www.mcescher.com/gallery/recognition-success/ ascending-and-descending/

Figure 39. (access in March 2018)

M.C. Escher, Waterfall ,1961, Lithograph. 300mm x 380mm.

http://www.mcescher.com/gallery/recognition-success/ (access in March 2018)

In addition, "spatial self-reference" like this can be expressed not only in visual perception but also in hearing. Canon is a method of composing music, for example, the well- known Brother John is a standard Canon. This picture was taken from the experimental animation "Canon" in 1964. The author, Norman McLauren, is the leading pioneer artist in the history of animation. The block of letter A appears first in the lens, and it rotates on the checkerboard, while playing the melody of Brother John, then it disappeared; Then there are blocks of letters B, C, and D，they sequentially

started to move completely along the path of A block; Each of them played their own Brother John, but their pitches were slightly different. This has a wonderful effect, four

Figure 40

paragraphs of Brother John are interlaced and stacked to create a new hearing effect.[30]

Figure 40. Figure 41.

The experimental animation "Canon" in 1964. Author: Norman McLauren

Explanation: letter A appears first on the checkerboard and playing the melody of Brother John. Then B, C, and D sequentially started to move completely along the path of A and played the Brother John each other, but their pitches were different.

https://m.douban.com/people/4291733/ (access in March 2018)

Figure 41

This is Canon. Several identical melodies have been unfolded gradually in time, and they have cooperated with each other at specific moments to produce new auditory effects. Due to the balanced position of multiple voices, this new effect tends to appear luxurious and elegant, and is a fairly common theme in Baroque music. It is not difficult to think that Canon's composing method is almost a space and time construction game. The cooperation of several voices is actually a combination of voice and self, which is equivalent to "self- reference of Space".

4.2.1 The Structural Similarity between Johann Sebastian Bach's and M.C. Escher's works

M.C. Escher's works have a perfect structural similarity with Baroque's composer Johann Sebastian Bach (1685–1750), which is "Infinity Rise". The greatest representative of Baroque music, Bach, wrote a considerable number of Canon, one of them, Crab Canon, could be written on the Mobius ring. Crab Canon is similar to M.C. esher's Mobius Strip II Red Ants. Crab Canon has exactly the same two voices,

[30] Douglas R. Hofstadter, (1999) "Gödel, Escher, Bach: An Eternal Golden Braid". New York: Basic Books.

however, one of the voices is going to play backwards, and if the two voices fall back after they finish, they can be endless.

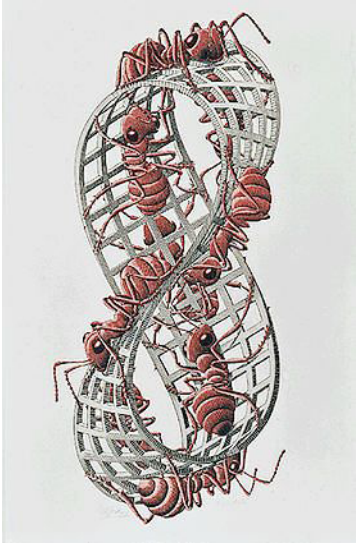


Figure 42.

M.C. Escher, Möbius Strip II ,1963

Woodcut in red, black and grey-green, printed from 3 blocks. 205mm x 453mm.

http://www.mcescher.com/gallery/recognition-success/ (access in March 2018)

The Shepard Tones in the acoustic illusion belongs to the self-reference of space, which was discovered by Sheppard, a psychologist and pioneer of space relations theory. Sheppard had predicted that this tone was the acoustic equivalent of the Necker cube illusion. The sound produces an effect similar to an endless rise or fall, the higher the tune, the higher it has never reached its peak, or it has plummeted, and it has not bottomed. The basic principle is to superimpose simple frequency sounds, let the bass fade in while the treble fades out, and also there is a middle tone that is always maintained. The result is that you can always hear two mixed rising melody, this single loop sounds like the tone of eternity. It is like a rotating drum of a barber shop, always rotating in place, but it seems to rise indefinitely.

In contemporary times, Hans Zimmer (1957– present), the master of soundtrack music, is also very good at using this technique of composition. For example, in 2011, Sherlock Holmes had an infinitely decreasing accompaniment that rendered intense tension; In 2014, Interstellar, when the tsunami struck, there was a period of music that was accelerating, approaching, and rising; In 2017, Dunkirk, rising ticks filled the entire film, successfully creating an unusually intense atmosphere of anxiety.

Overall, we can see that regardless of self- reference in mathematical logic, the fugue in music, and pun in painting, they are all related to each other. They are exploring the same essence in their own different fields, that is the self-reference of space.

4.2.2 The relation between the Self-reference of Set theory and Optical illusion (Fraser Spiral illusion and Necker Cube illusion)

M.C. Escher has a famous engraving called Dragon, the dragon's tail and neck drilled out the two-dimensional plane where the prints were located and bitten in three-dimensional space. (*Fig.43*). This obviously constitutes an infinity symbol "∞", it can be seen that M.C. Escher's Dragon is a self-engulfing snake or called an "Ouroboros". An Ouroboros like this that is bent into a ring is an ancient symbol of the world (*Fig.44*).

Figure 43.

M.C. Escher, Dragon, 1952

Wood-engraving, on Japanese paper, with full margins 14 1/10 × 11 3/5 in 35.9 × 29.5 cm

http://blog.sciencenet.cn/blog-1208826-818298.htm (access in March 2018)

Figure 44.

M.C. Escher, China's Jade Dragon

It is an ancient symbol of the Ouroboros.

http://www.cguwan.com/show-649-120249-1.html (access in March 2018)

The earliest known example appeared on the gold-plated coffin of Tutankhamun (1341 BC—1323 BC) in the New Empire Period of Egypt. The Egyptian sun god Ra and the god of life Osiris t into a giant god that his neck and ankles were each wrapped around such an Ouroboros.

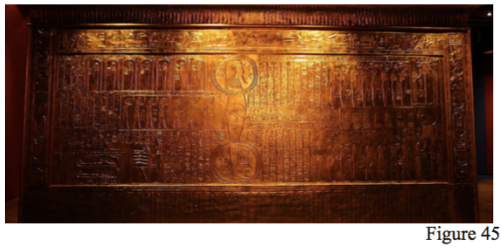


Figure 45

Figure 46

Figure 47

Figure 45. Figure 46. Figure 47.

Gold-plated coffin of Tutankhamun

A giant god that his neck and ankles were wrapped around an Ouroboros.

http://www.soul-guidance.com/houseofthesun/ouroboros.html (access in March 2018)

What is concerned here is not the content of the Ouroboros, but its form. The exploration of "self-reference" is an important type in M.C. Escher's work, a general example is the Hands, (*Fig.48*), one of the core concepts of Escher's performance is self-replication. Two hands paint each other, the way they paint each other is to think and construct their own ways. This violated the essence of set theory at the time: If the "painting hand's hand" is a set and the "painting hand" is another set, which of the two hands should belong to? Can a set be made up of elements that do not belong to its own? This is the "Russell' s Paradox" of mathematical logic. But rather than mathematics, it is more cognitive science.

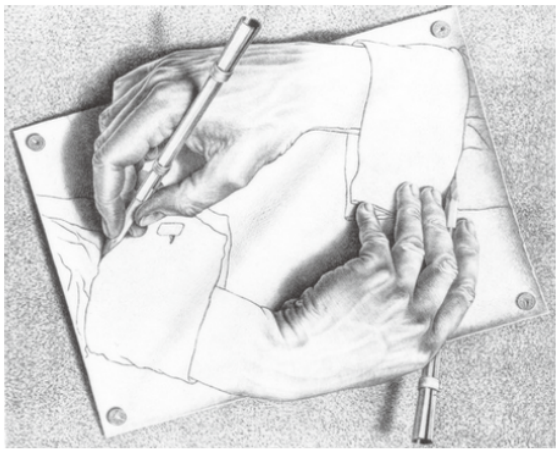


Figure 48.

M.C. Escher, Drawing Hands, 1948

Lithograph. 332mm x 282mm.

http://www.mcescher.com/gallery/back-in-holland/drawing-hands/ (access in March 2018)

M.C. Escher really likes to create such "self- referential" works. In this self-reference of set theory, he even encountered a difficult problem that could not be solved in his life: In this Gallery ,(Fig.49)， if "in-picture" and "out-of-picture" are regarded as two sets, then what kind of set does the person watching the painting belong to? M.C. Escher apparently did not know what to do with the middle of the picture and left it white. It was until the 21st century that contemporary mathematicians made up for it. The original central circle hides a recursive structure. (*Fig.50*). Otherwise, Esther has got involved in the research of Topology. This painting illustrated a young man looking at a painting in a gallery while he is actually inside a painting. M.C. Esher use Topology transformation to create this image, which exactly like a stretched painting was drawn on elastic material.

Figure 49.

M.C. Escher, Print Gallery, 1956

Lithograph. 317mm x 319mm.

http://www.mcescher.com/gallery/recognition-success/print-gallery/ (access in March 2018)

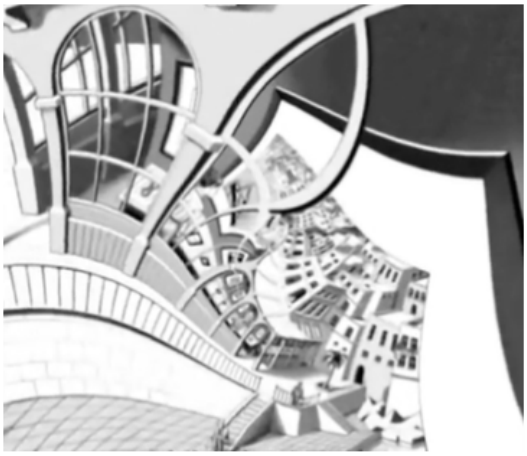


Figure 50.

The original central circle hides a recursive structure. Contemporary mathematicians made up for it.

https://funnyjunk.com/Tinder+problems/funny-pictures/5608559/ (access in March 2018)

Fraser Spiral illusion is visually the same as Gallery's recursive structure, but Fraser Spiral illusion is not connected between each arc. (Fig.49). It is a series of concentric circles, which involves perception and action in cognitive sciences. Perception is extracting information from the senses, such as the Necker Cube illusion, ambiguous shapes can spontaneously convert perspective. In turn, Necker Cube illusion is related to the multistable perception of Gestalt psychology, that is, the experience of vague perception, and the instability between two or more explanations.

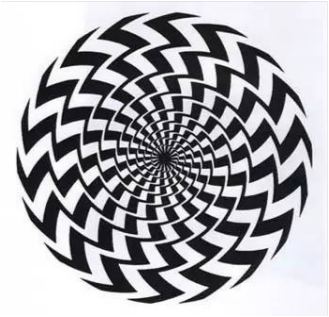


Figure 51. Fraser spiral illusion

Fraser spiral illusion http://www.sohu.com/a/119004603_224832 (access in March 2018)

4.3 Using the Tessellation pattern to create complicated works

M.C. Escher's unique style comes from his unique experience, he studied with the print artist Samuel Jesserun de Mesquita in 1919. Then he left his hometown in 1922 and went to Italy and Spain to study. He visited the splendid Alhambra Palace in Granada that was built in the 13th century and It is the royal palace ruled by the Moors. The Palace perfectly combines the secular Islamic architecture with the Arab palace courtyard. M.C. Escher saw numerous intricate mosaics in here and became obsessed with it, his endless inspiration came from the gorgeous mosaics of the Alhambra.

This unique art originated from ancient Roman tile collages and Persian interwoven patterns. After the Arab conquest, it combined advanced astronomy and geometry, and from the 9th century onwards it developed into an exceptionally orderly decoration. The physicist E.S. Fedorov discovered seventeen different symmetrical patterns of tessellation planes in 1892. And In 1924, the mathematician George Pólya's paper once again confirmed these seventeen methods. M.C. Escher understood the seventeen symmetry groups, and then made forty-three drawings according to them.

4.3.1 Exploring the pattern of Regularity Tessellation

Tessellation is a geometric concept that means filling a surface with a series of shapes without a gap. Filling a surface periodically with one or more polygons is a fairly simple type. M.C. Escher has a lot of works to explore the polygonal tessellation, the more famous such as Lizard and Bird Fish. (Fig.52) (Fig.53)

Its basic method is very simple. (Fig.54) (Fig.55) (Fig.56) It is to use a ruler to draw polygonal tessellation such as triangles, quadrilaterals, and hexagons on the plane, then give each polygon an elaborate pattern, so that it constitutes a decorative pattern with both order and rhythm to a greater extent. The pattern can be extended indefinitely, which symbolizes eternality in Islamic culture.

His most famous works *Sky and Water*, *Day and Night* explored a gradient polygon tessellation. These works focus on the main features of M.C. Escher's works: between two-dimensional and three-dimensional, realistic scenes and abstract mosaics, as well as the gradient between the geometry and the figurative graphic. (Fig.57) (Fig.58)

Figure 52

Figure 53

Figure 52. M.C. Escher, Lizard (No. 25), 1939
India ink, pencil, watercolor.
http://www.mcescher.com/gallery/switzerland-belgium/no-25- lizard/ (access in March 2018)
Figure 53. M.C. Escher, Bird / Fish (No. 22), 1938
India ink, colored pencil, watercolor.
http://www.mcescher.com/gallery/switzerland-belgium/no-22-birdfish/ (access in March 2018)

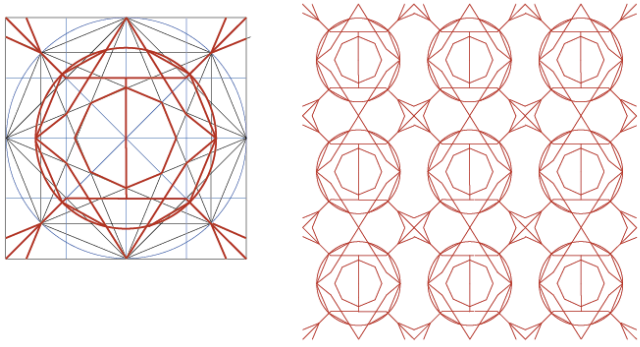
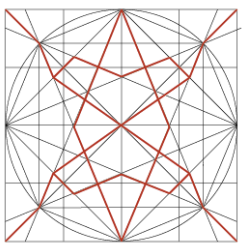


Figure 54



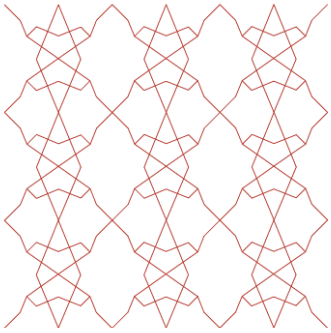
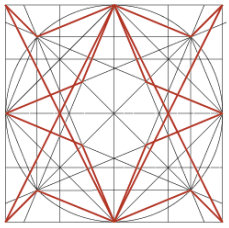


Figure 55



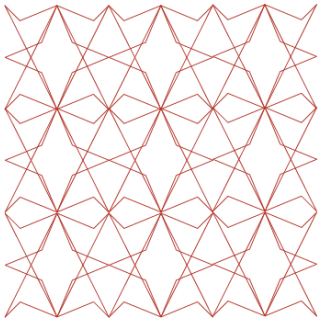


Figure 56

Figure 54. Figure 55. Figure 56.

Use a ruler to draw polygonal tessellation, then give each polygon an elaborate pattern, it will be constituting a decorative pattern.

Be made by Haoran Li.

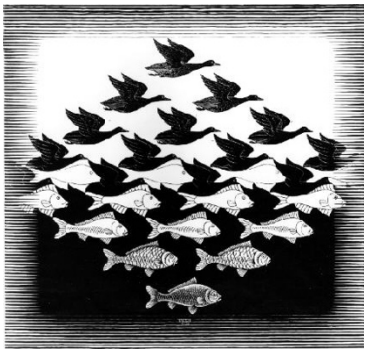


Figure 57.

M.C. Escher, Sky and Water I ,1938,

Woodcut. 439mm x 435mm.

http://www.mcescher.com/gallery/switzerland- belgium/sky-and-water-i/ (access in March 2018)

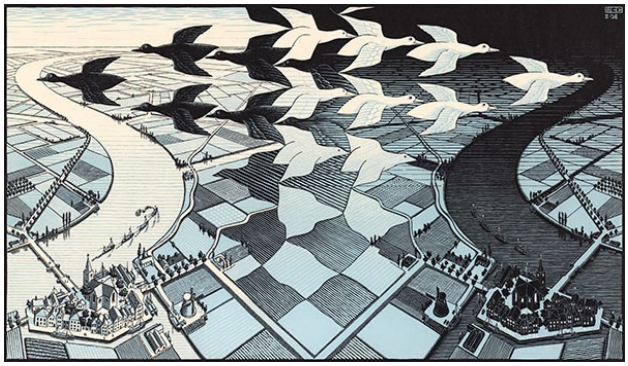


Figure 58.

M.C. Escher, *Day and Night,*1938

Woodcut in black and grey, printed from 2 blocks. 677mm x 391mm.

http://www.mcescher.com/gallery/switzerland-belgium/day-and-night (access in March 2018)

4.3.2 Aperiodic Tessellation

In fact, Tessellation has more complicated patterns, namely Aperiodic Tessellation. That is using a finite variety of polygons that are never repeated, such as "Penrose mosaic"， (Fig.59)，It is very common in mosaic collages of Islamic architecture，It is called "گره " in Persian, meaning "knotting".

M.C. Escher's prints in Penrose mosaic of little use, however, he has more particularly hyperbolic paraboloid tessellation. Hyperbolic parabolic surface is also called saddle surface. The more visualized explanation is that it is the result of a at internal shrinkage deformation. More generally, barreled chips are the shape.

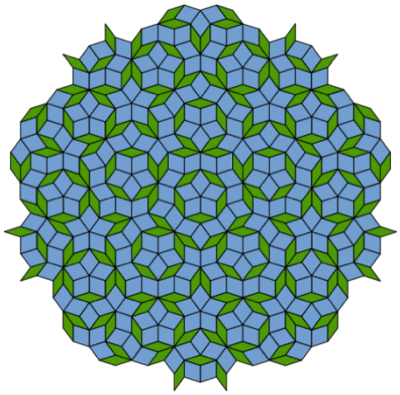


Figure 59.

Penrose mosaic

https://www.guokr.com/article/69740/?page=3 (access in March 2018)

M.C. Escher's "Circular Limit" series of works was applied to hyperbolic paraboloid. Prints can only be carved on flat wooden boards, and M.C. Escher tries to construct a kind of projection in order to represent hyperbolic paraboloid. In other words, by squashing the hyperbolic paraboloid on a plane, there will be a central expansion and

contraction around the projection pattern. The original straight line on the parabola turns into a curve, and the original repeat pattern in an infinite space becomes a fractal pattern in a finite space.

Specifically, in the “Circular Limit” series, Canadian mathematician Harold Coxeter (1907- 2003) inspired M.C. Escher’s inspiration. Octagonal 6th-order square mosaic also known as Tetragonal six-order four diamond mosaic, because it is a sixth-order four diamond mosaic restructured by tetragonal transformation. (Fig.60) M.C. Esher’s circle limit IV is drawn with this kind of symmetry. In this image where angles’ and bats’ heads and wings are designed and calculated to be artfully positioned on vertexes of the octagonal 6th-order square mosaic. (Fig.61)

Circle limit III was drawn with alternated octagonal tiling. Alternated octagonal tilling is an octagonal mosaic restructured by Interlaced transformation. (Fig.62) Every curve in Circle Limit III pass through the center of every fish, which constructed Regular quadrilateral and regular triangle on the alternated octagonal tiling. (Fig.63)

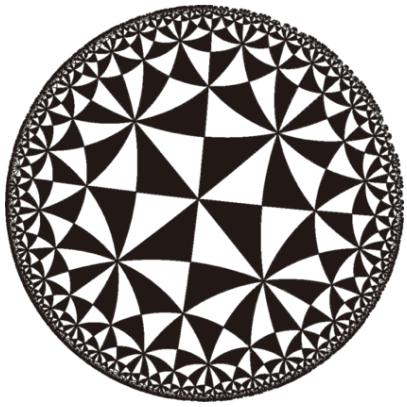


Figure 60.

Octagonal 6th-order square mosaic

http://www.taodabai.com/469666291.html (access in March 2018)

Figure 61.

M.C. Escher, *Circle Limit IV,* 1960

Woodcut in black and ocre, printed from 2 blocks.

http://www.mcescher.com/gallery/recognition-success/circle (access in March 2018)

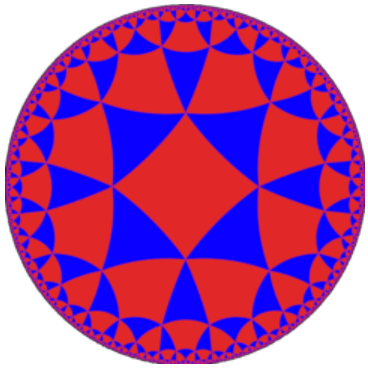


Figure 62.

Alternated octagonal tiling

http://www.taodabai.com/65964104.html (access in March 2018)

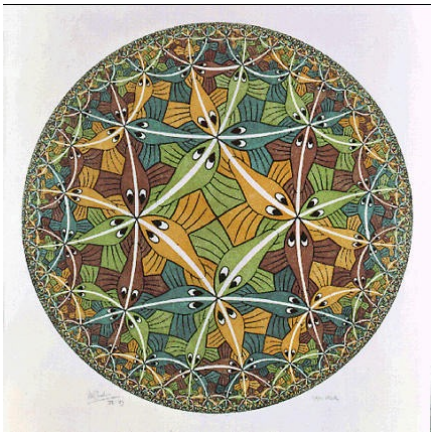


Figure 63.

M.C. Escher, *Circle Limit III,* 1959

Woodcut, second state, in yellow, green, blue, brown and black, printed from 5 blocks.

http://www.mcescher.com/gallery/recognition-success/circle- limit-iii/ (access in March 2018)

5.Analyze the regularity of Graphic design of visual illusion (Fraser spiral illusion, Necker cube, Negative space illusion, Hering illusion) from the Systemmic view

5.1 Analyze the shape and form of Poggendorff illusion and Hering illusion from the geometric view

The Hering illusion is also called 'Divergence line illusion'. The Hering illusion is the distortion of the simple cells in the primary visual cortex in space, which is caused by the time delay in the visual system. It was discovered by the German physiologist Ewald Hering in 1861. The two parallel lines are curved due to the oblique line. Hering illusion is similar to the Poggendorff illusion and the Müller-Lyer illusion. All these illusions demonstrate how lines can seem to be distorted by their back- ground.[31]

Poggendorff Illusion, It is named after Johann Christian Poggendorff , the editor of the journal, who discovered it in the figures Johann Karl Friedrich Zöllner submitted when first reporting on what is now known as the Zöllner illusion , in 1860.[32] The magnitude of the illusion depends on the properties of the obscuring pattern and the nature of its borders.[33] Poggendorff Illusion is an optical illusion caused by apparent misplacement.(Fig.64), The thinner two lines are behind the yellow color blocks, when looking at (a), the black and blue lines appear to be aligned, but in fact the black and orange lines in figure (b) are aligned.Fig.65), in (c), depending on the angle of the α, the strength of the illusion effect is determined. For example, the angle of inclination of the diagonal in (d) is 30°, and the effect of changes in the density and diagonal illusion more strongly. In (e) the angle of inclination of the diagonal is 60°, and the diagonal density and illusion effects are relatively weak.

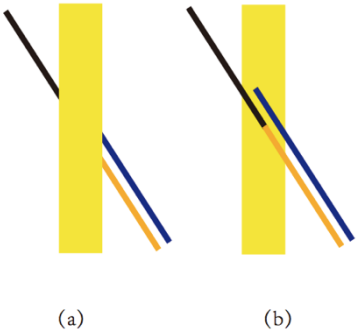


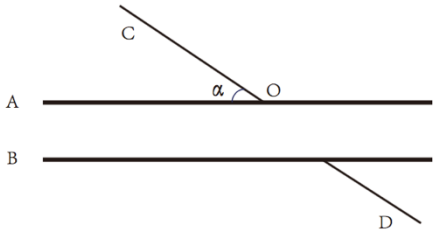
Figure 64.

Poggendorff Illusion, when looking at (a), the black and blue lines appear to be aligned, but in fact the black and orange lines in figure (b) are aligned.

[31] Eagleman, David M. (December 2001). "Visual illusions and neurobiology" (PDF). Nature Reviews Neuroscience. 2: 920–926.

[32] Zöllner F (1860). "Ueber eine neue Art von Pseudoskopie und ihre Beziehungen zu den von Plateau und Oppel beschriebenen Bewegungsphaenomenen". Annalen der Physik. 186 (7): 500–25.

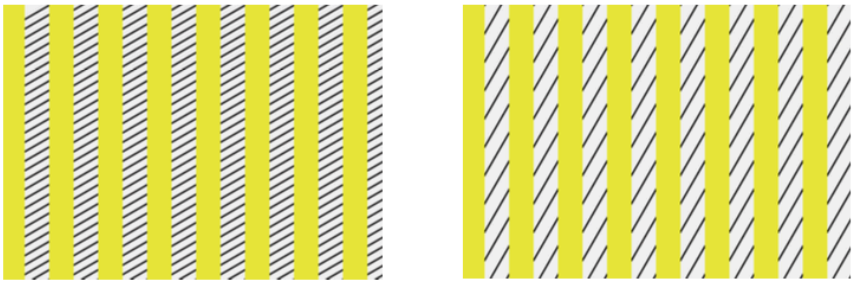
[33] Westheimer G, Wehrhahn C (1997). "Real and virtual borders in the Poggendorff illusion". Perception. 26 (12): 1495–501.



(c)

Figure 65.

Depending on the angle of the α, the strength of the illusion effect is determined.



(d) (e)

Figure 65.

The angle of inclination of the diagonal in (d) is 30°, and the effect of changes in the density and diagonal illusion more strongly. In (e) the angle of inclination of the diagonal is 60°, and the diagonal density and illusion effects are relatively weak.

http://www.michaelbach.de/ot/ang-poggendorff/index.html (access in April 2018)

As shown in(Fig.66), it can be clearly seen (f) as the diagonal angle of inclination is small, the resulting effect is more obvious than the illusion (g). As shown in (Fig.67), this is experimental data obtained from statistics.[34] In figure (h), $\Delta<0$ and $\Delta>0$ indicate the range of optical illusion, that is, Poggendorff Illusion can appear within this range. In figure (i), α represents the angle between the interrupted diagonal and the straight line. It can be seen from the figure that when α is 26.6°, the range of $\Delta<0$ and $\Delta>0$ is the largest. When α is 63.4°, the range of $\Delta<0$ and $\Delta>0$ is the smallest. In figure (j), w is the width between the parallel lines. The larger the w, the greater the range of visual illusion $\Delta<0$ and $\Delta>0$.

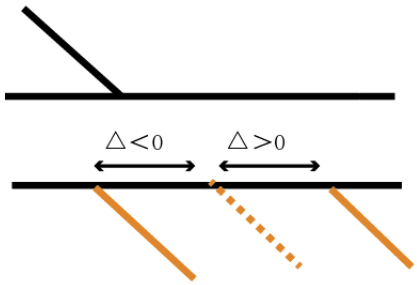
(f) (g)

[34] Gregory R L, (1974) Concepts and Mechanisms of Perception (London: Duckworth)

Figure 66.

Figure (f) as the diagonal angle of inclination is small, the resulting effect is more obvious than the illusion (g).

http://www.pnas.org/content/102/21/7707 (access in April 2018)



(h)

Figure 67.

∆<0 and ∆>0 indicate the range of optical illusion, Poggendorff illusion can appear within this range.

http://www.pnas.org/content/102/21/7707 (access in April 2018)

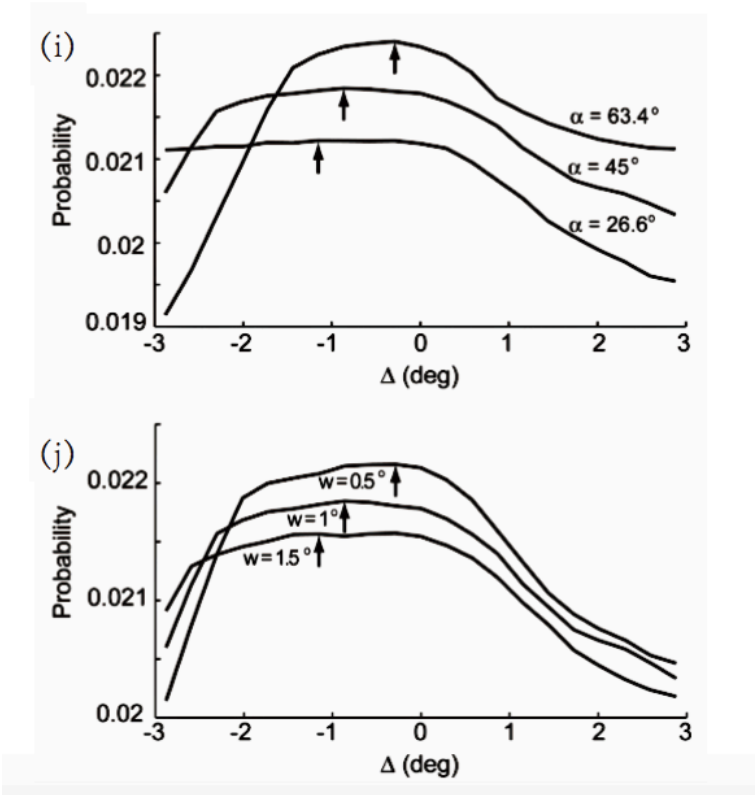


Figure 67.

In figure (i), α represents the angle between the interrupted diagonal and the straight line. In figure (j), w is the width between the parallel lines.

http://www.pnas.org/content/102/21/7707#F1 (access in April 2018)

5.1.1 Exploring the regularity of pattern structure in Herring illusion

Herring illusion evolved from Poggendorff Illusion and they have the same principle of production. As shown in (Fig.68), segments e_1, e_2, and e_3 are optical illusions produced by the intersection of line E and $\angle F_1O_1E$, $\angle F_2O_2E$, and $\angle F_3O_3E$. The extent of optical illusion depends on the width of line E and the degree of the tilt angle, the smaller the angle, the greater the optical illusion. Herring illusion uses this principle to make the straight lines have an illusion of curve. The strength of the curve depends on the angle of inclination. The smaller the angle, the larger the curve. As shown in (Fig.69), the inclination angle with the straight line is 7°, and thereafter each multiple of 7° is gradually increased, and the formed curve is significantly more curved than (Fig.70). In addition, the thickness of the straight line also affects the extent of the curve, in(Fig.71), the curve produced by the thicker straight-line E is significantly larger than the straight-line F, this is related to 'W' in figure (j), the larger the 'W', the greater the range of visual illusion $\Delta<0$ and $\Delta>0$. In(Fig.72), the straight lines G and H are curved outwards. The closer to the edge, the smaller the angle of inclination, the more obvious the optical illusion is. [35]

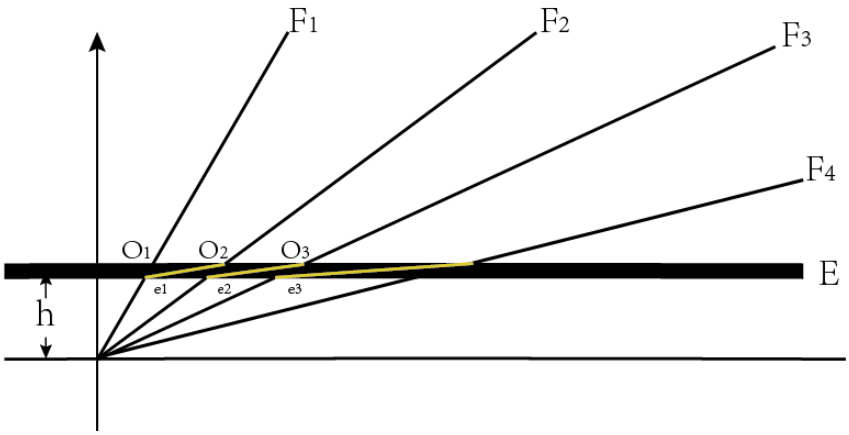


Figure 68.

Segments e1, e2, and e3 are optical illusions produced by the intersection of line E and ∠F1O1E, ∠F2O2E, and ∠F3O3E. The extent of optical illusion depends on the width of line E and the degree of the tilt angle,

Be made by Haoran Li

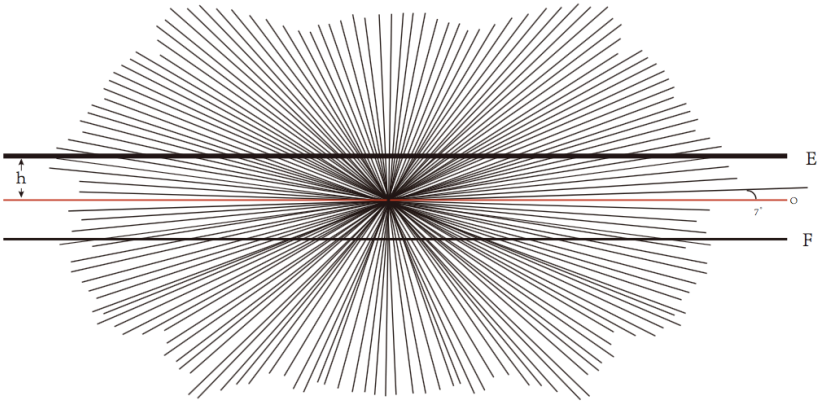


Figure 69.

[35] Ganz L, (1966) "Mechanisms of the figural aftereffects" Psychological Review 73 128–150

The inclination angle with the straight line is 7°, and thereafter each multiple of 7° is gradually increased, and the formed curve is significantly more curved than Figure 70.

The curve produced by the thicker straight-line E is significantly larger than the straight-line F,

Be made by Haoran Li

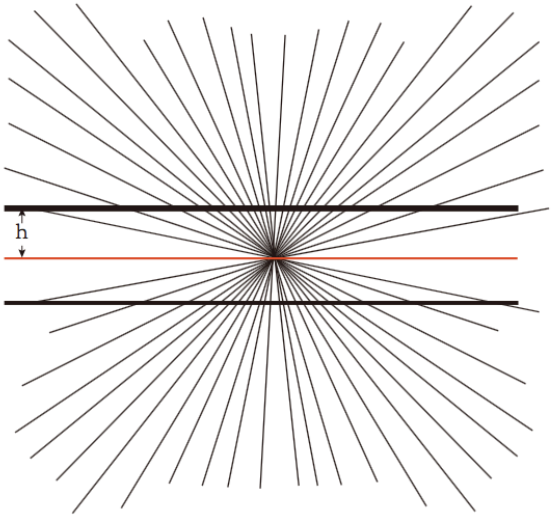


Figure 70.

Be made by Haoran Li

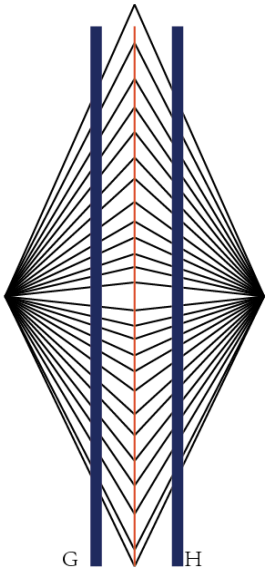


Figure 71.

The straight lines G and H are curved outwards. The closer to the edge, the smaller the angle of inclination, the more obvious the visual illusion is.

Be made by Haoran Li

5.2 Analysis of the causes of Fraser spiral illusion through graphical structure analysis

When observer looking at the Fraser spiral, there seems to be a twisted spiral constructed by black curves. In fact, the "spiral" is a series of concentric circles. James Fraser overlaps a set of concentric circles and a specific background that created a spiral visual effect. This effect is enhanced by the spiral tessellation background. Like other kinds of visual illusions, twisted spirals are caused by the illusion of deviations of visual nerve, which produced by the staggered curve elements in concentric circles. The red spiral curve in(Fig.72) represents the spiral visual effect on concentric circles of Fraser spiral illusion. The spiral is a clockwise spiral. In the visual effect, the spiral line converges indefinitely to the concentric circle. The spiral effect appears on remote side of viewer's vision focus in the figure. When the spiral effect is most severe when the visual focus is at the center of the picture. In this process, any part of the concentric circles of(Fig.72) is guiding the spiral of our vision along this spiral, eventually leading to the creation of the Fraser spiral illusion. From the standpoint of form, Fraser spiral illusion consists of two parts, namely spiral lines (actually concentric circles) and black and white gray background images. The following section explores the formation principle by decomposing and deconstructing the Fraser spiral illusion.

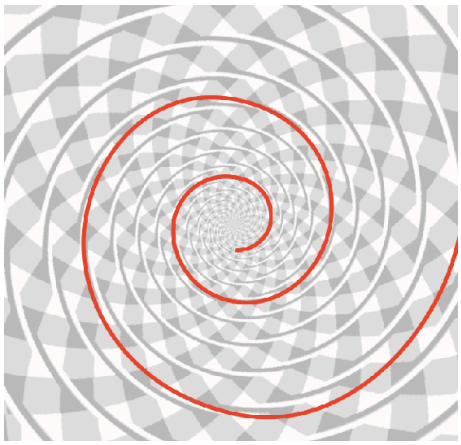


Figure 72.

When the black arc segment on the concentric circles is extended clockwise, it is connected to the inward black arc segment. The red spiral is the result of the connection of each black arc.

Be made by Haoran Li.

5.2.1 Analysis of Fraser spiral illusion on the aspect of Gestalt psychology

Gestalt Psychology claims that when the human perceptual system forms a precept, the whole has a reality of its own, independent of the parts. A key principle in Gestalt psychology is Reification. This perceptual experience is the result of interactions between various stimuli, including more external spatial information. Based on the gestalt theory, the classic Fraser spiral illusion could be disassembled and composed.

The method of compositing：the concentric circles in (Fig.73) actually is composed of a number of short curves regularly intertwined at a specific angle. Based on the gestalt reification principle, the series of oblique elements causes viewer's visual nerve incorrectly perceived the image and the vision system treats the virtual outline as a "real" outline. In(Fig.74), the black triangle is added to the inner and outer sides of each short curve, and the size decreases with the reduction of the curve, causing the black and white circles intertwined into a helical visual illusion, but actually each circle is independent. (Fig.75) is formed by colour inversion of (Fig.74), with a checkerboard background. (Fig.76) is the effect of (Fig.75) overlapped on (Fig.73) and(Fig.74) then rotated by 12 degrees, then a Fraser spiral illusion is formed.

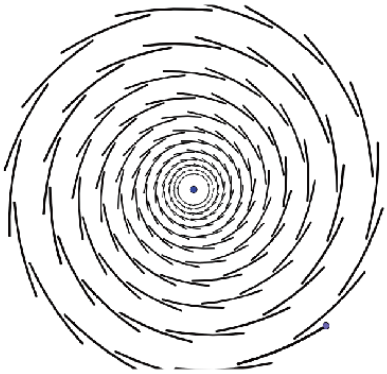


Figure 73

Figure 74

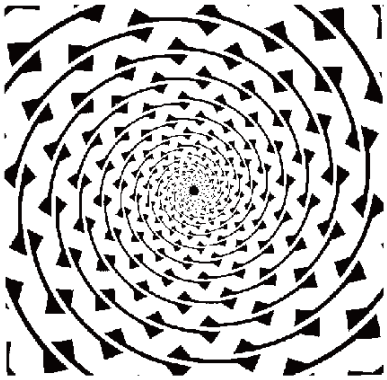


Figure 75

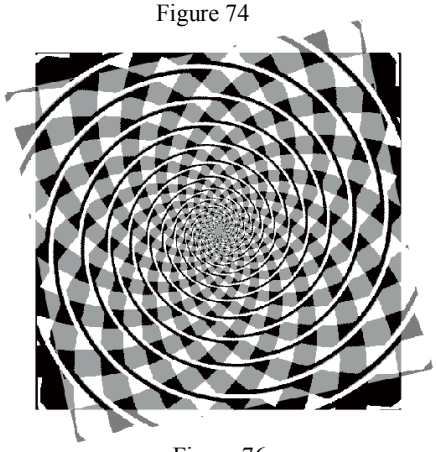


Figure 76

Figure 73. "concentric circles" is composed of a set of arc segment regularly intertwined at a specific angle.
http://www.360doc.com/content/10/0515/11/720362_27686277.shtml (access in April 2018)

Figure 74. The black triangle is added to the inner and outer sides of each short curve, and the size decreases with the reduction of the curve.
https://foundationsofvision.stanford.edu/chapter-11-seeing/ (access in April 2018)

Figure 75. Be formed by colour inversion of Figure 74.
http://psylux.psych.tu-dresden.de/i1/kaw/diverses%20Material/www.illusionworks.com/html/fraser_spiral.html (access in April 2018)

Figure 76. Figure 75 overlapped on Figure 73 and Figure 74 then rotated by 12 degrees, then a Fraser spiral illusion is formed.
Be made by Haoran Li.

The method of disassembling：As shown in (Fig.77), (Figure a) is split into a checkerboard background (Figure b), an circle composed with triangles (Figure c), and spiral concentric circle(Figure d). Then b+c+d=a.

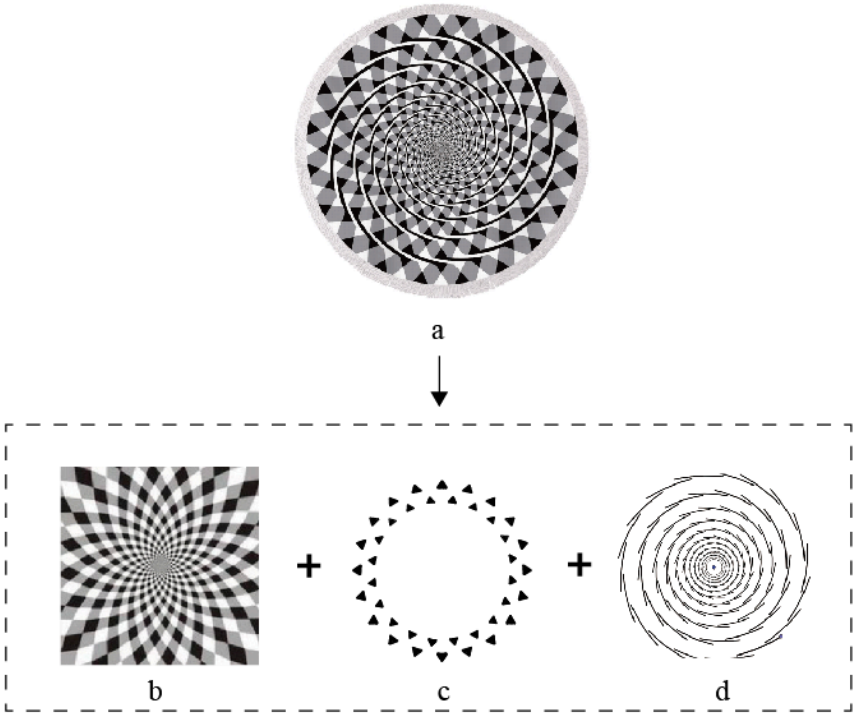


Figure 77

Figure 77.

Figure a. Fraser spiral illusion

https://it.pinterest.com/pin/239887117622943616/?lp=true (access in April 2018)

Figure b. A checkerboard background image is split by Figure a.

http://www.360doc.com/content/10/0515/11/720362_27686277.shtml (access in April 2018)

Figure c. Circles are composed with triangles.

Be made by Haoran Li.

Figure d. “concentric circles” is composed of a set of arc segment regularly.

http://www.360doc.com/content/10/0515/11/720362_27686277.shtml (access in April 2018)

5.2.2 Angle analysis of spirals in Fraser spiral illusion

The Fraser spiral illusion phenomenon is created by the visual nerve and brain image processing. Tilt angle of the curve in the concentric circle affects the perception image. It can be clearly seen from (Fig.78) and (Fig.79) that the tilt angle of the curve in the concentric circle is different, which affects spiral illusion effect. Since the tilt angle of(Fig.78) is smaller, the resulting spiral effect is stronger than(Fig.79).

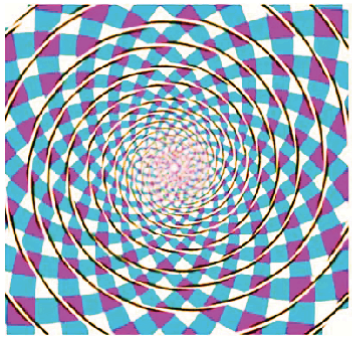


Figure 78

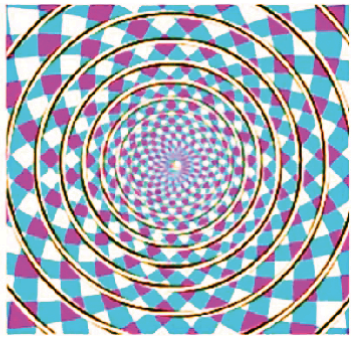


Figure 79

Figure 78. The smaller tilt angle of the curve is, the stronger resulting of spiral effect will be.
https://www.frontiersin.org/articles/10.3389/fnhum.2015.00374/full (access in April 2018)
Figure 79. The bigger tilt angle of the curve is, the weaker resulting of spiral effect will be.
https://www.frontiersin.org/articles/10.3389/fnhum.2015.00374/full (access in April 2018)

Based on the study of GW STUART and RH DAY,[36] as shown in(Fig.80), the x-axis represents the tilt angle, and the y-axis represents the visual illusion strength. From the figure, it can be clearly seen that when the tilt angle is 12 degrees the illusion strength is the highest. (Fig.81), Illustrated that the effect of generating optical illusion under the condition of 12 degrees is the most obvious compared with 8°, 12°, 18° ,25°, 35°.

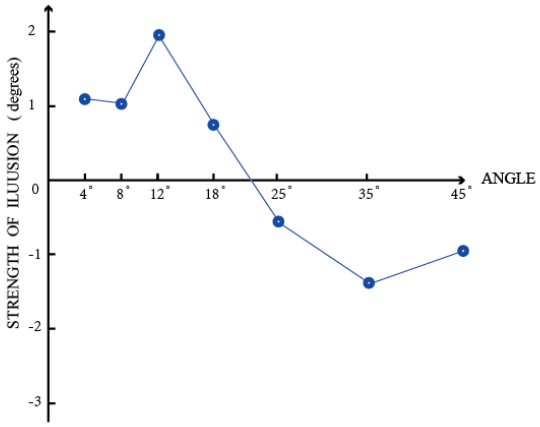


Figure 80

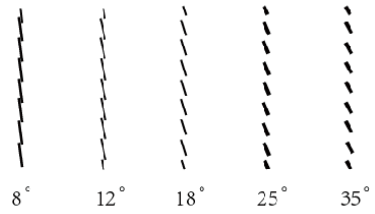


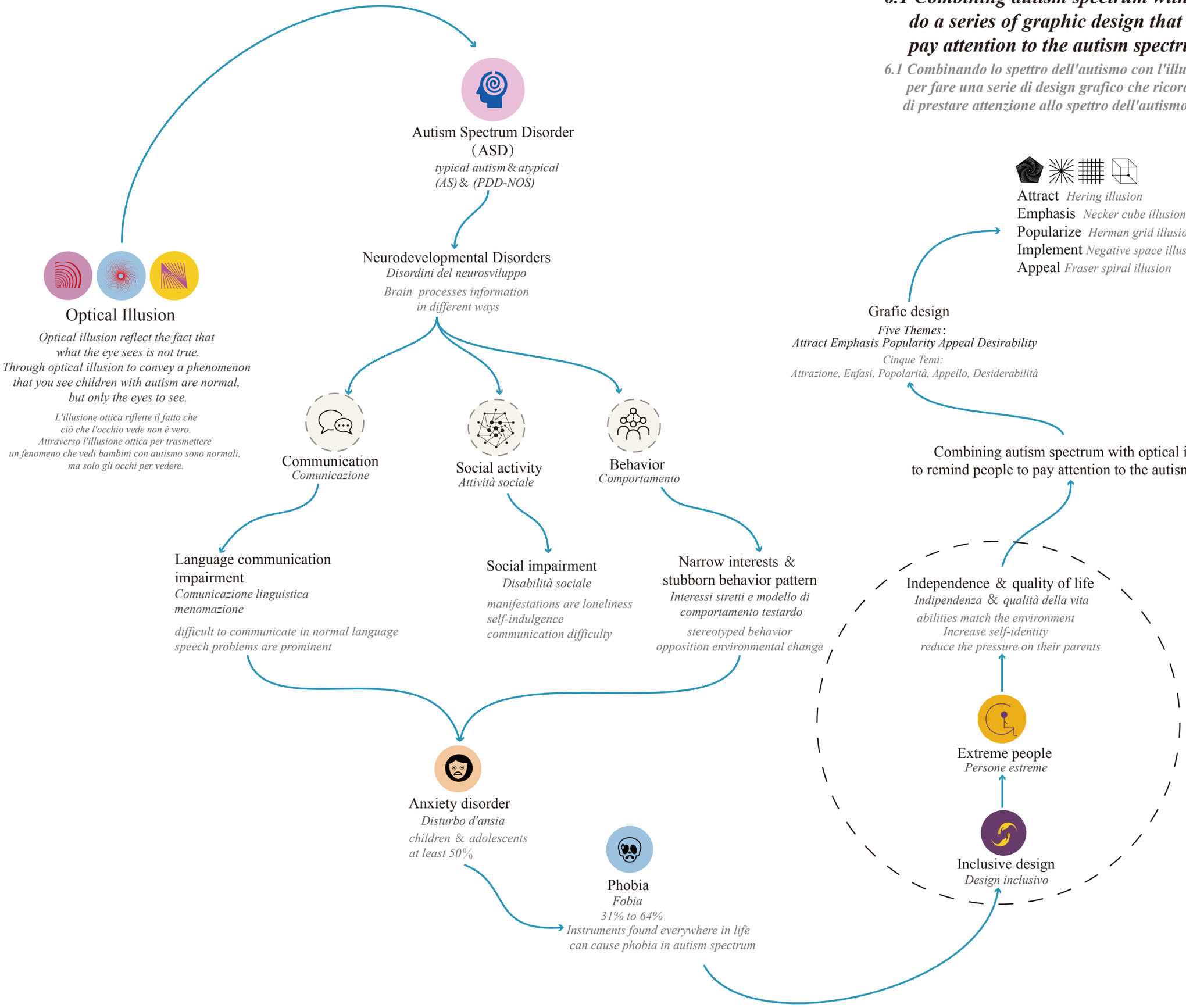
Figure 81

Figure 80. The x-axis represents the tilt angle, and the y-axis represents the optical illusion strength.
Figure 81. When the tilt angle is 12 degrees the illusion strength is highest.

[36] G. W. STUART and R. H. DAY (1988) Monash University, Clayton, Victoria, The Fraser illusion: Simple figures Perception & Psychophysics. 44 (5), 409-420

6.1 Combining autism spectrum with optical illusion, to do a series of graphic design that remind people to pay attention to the autism spectrum.

6.1 Combinando lo spettro dell'autismo con l'illusione ottica, per fare una serie di design grafico che ricorda alle persone di prestare attenzione allo spettro dell'autismo



The diagram was made by Li Haoran

6. Optical illusion graphic design in a visual way of production associated with the Autism spectrum.

Optical illusion refers to the fact that what the eye sees is not true, thus, the project through optical illusion to convey a phenomenon that you see children with autism are normal, but only the eyes to see. In fact, they have different levels of capacity loss, therefore, we must pay attention to them through appearances. To increase ordinary people's understanding and respect for autism spectrum and reduce the mismatch between autism spectrum ability and the environment. The ordinary people and designers are urged to pay attention to autism spectrum, because one of the greatest prejudice of designers is to consider only the needs of ordinary people. By giving the special user the autonomy and independence they deserve, their capabilities are matched to the environment.

6.1 Combining autism spectrum with optical illusion, to do a series of graphic design that remind people to pay attention to the autism spectrum.

6.2 Through the theoretical analysis and investigation of the Autism spectrum, the causes of autism spectrum anxiety and the conditions that make them feel comfortable are summarized.

Autism Spectrum Disorder (ASD), It is broadly defined based on the core symptoms of typical autism. It includes both typical autism and atypical autism, Asperger syndrome(AS), and Pervasive developmental disorder not otherwise specified (PDD-NOS).[37] Autism spectrum disorder refers to the related behavior of autism as a pedigree, ranging from low to high. At the low end, it is “typical autism”, and high-end is gradually approaching the ordinary people. Globally, of 2015, autism is estimated to affect 24.8 million people.[38] Early speech or behavioral interventions can help children with autism acquire self-care, social and communication skills.[39] Although there is no known treatment, some children have recovered from the condition.[40]

Autism, it is a highly variable neurodevelopmental disorder.[41] It appears for the first time in infancy or childhood, and it generally continues a stable process without remission.[42] Autism Spectrum's brain develops and processes information in different

[37] Johnson CP, Myers SM (2007). "Identification and evaluation of children with autism spectrum disorders". Pediatrics. 120 (5): 1183–215.

[38] GBD 2015 Disease and Injury Incidence and Prevalence, Collaborators. (8 October 2016). "Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015". Lancet. 388 (10053): 1545–1602.

[39] Myers SM, Johnson CP (2007). "Management of children with autism spectrum disorders". Pediatrics. 120 (5): 1162–82.

[40] Silverman C (2008). "Fieldwork on another planet: social science perspectives on the autism spectrum". BioSocieties. 3 (3): 325–41.

[41] Geschwind DH (2008). "Autism: many genes, common pathways?". Cell. 135 (3): 391–5.

[42] "F84. Pervasive developmental disorders". (2007) ICD-10: International Statistical Classification of Diseases and Related Health Problems: Tenth Revision. World Health Organization. Archived from

ways. Therefore, they have major challenges in communication, social activity, and behavior. Symptom can be severe and interfere with daily work, or symptom can only cause minor problems. The core symptoms of typical autism are mainly reflected in three aspects: social impairment, language communication impairment, narrow interests and stubborn behavior pattern.[43] The specific manifestations are loneliness, self-indulgence, and communication difficulty; It is difficult to communicate in normal language, and speech problems are prominent; Also demonstrated in narrow interest and stereotyped behavior, as well as opposition to environmental change; Atypical autism is not completely include in the three aspects mentioned above, but only one or two of them.

Anxiety disorder is a common coexistence problem in children and adolescents with autism spectrum disorders (ASD). Although prevalence varies from 11% to 84%, and most researches show that approximately half of children with ASD have at least one anxiety disorder. Of all types of anxiety disorder, specific phobia is the most common and the incidence is estimated to be between 31% and 64%. In contrast, the estimated range of children phobia in the ordinary people is 5% to 18%.[44] Instruments found everywhere in life can cause phobia in autism spectrum, such as elevator, vacuum cleaner, tap water, gas burner, mechanical toy, egg beater, etc. From this we know that autism spectrum has very different ways of perceiving, experiencing, and responding to the world. Therefore, we need to reduce factors that cause anxiety and phobia in autism spectrum in public space.

6.3 Combining autism spectrum with optical illusion, to do a series of graphic designs that reminds people to pay attention to the autism spectrum.

In a Mayes＆Calhoun survey, 50% to 73% of children with autism has an obvious delay in their sport function and communication compared with normal children in the same age group.[45] Dyskinesia is related to the independence and quality of life of these patients. Most people affected by the disease are still unable to live independently and need family or community support.[46] Therefore, this project will remind the ordinary people and designers to pay attention to the universal design while also paying attention to extreme people through the combination of graphic design and visual illusion. That is, focus on autism spectrum disorder (ASD), provide more inclusive design and try

the original on 21 April 2013. Retrieved 10 October 2009.

[43] Autism Spectrum Disorder, 299.00 (F84.0). (2013) In: American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. American Psychiatric Publishing.

[44] Mayes, SD, Calhoun, SL, Aggarwal, R., Baker, C., Mathapati, S., Molitoris, S., & Mayes, RD (2013). Unusual fears in children with autism. Research in Autism Spectrum Disorders , 7 , 151–158.

[45] Mayes, S.D. and Calhoun, S.L. (2003) Ability Profiles in Children with Autism: Influenced of Age and IQ. Autism, 7, 65-80.

[46] Ozand, P.T., Al-Odaib, A., Merza, H. and Al Harbi, S. (2003) Autism: A Review. Journal of Pediatric Neurology, 1, 55-67.

their best to provide autism spectrum with the deserving autonomy and independence in public space. Meanwhile, making the autism spectrum "integrate" into the general public's environment so that their abilities match the environment and improve self-care capabilities. On the other hand, the public's concern for autism spectrum will also reduce the pressure on their parents.[47]

6.3.1 Autism spectrum graphic design concept

From the optical illusion of expression and the overall perspective, the project is divided into five themes: Attraction, Emphasis, Popularity, Implement and Appeal, which means, AEPIA. Each theme corresponds to a kind of optical illusion. Attraction corresponds herring illusion because that herring illusion is easily to evoke a sense of concentration to viewer. The main emotion of autism spectrum is fear, any small thing in public place will cause any different degree of autistic children fear and everything around them is like a kaleidoscope. Their senses (vision, hearing, touch, smell, and taste) get too much information from the surrounding environment. Therefore, combine this form with the main symptoms of autism spectrum and make a graphic design that draws people's attention to them. Next, the subject of Emphasis is represented by Necker cube illusion. It mainly emphasizes the state of autism spectrum in public place and to express the complexity and confusion of the external world in the perception of autism spectrum. Afterwards, the subject of Popularity is represented by Herman grid illusion, the blur and uncertainty of the Herman grid illusion are shown in an exaggerated form with a magnified effect, in order to express autism spectrum's sense of tension due to ambiguity and uncertainty. Subsequently, the subject of Appeal is represented by Fraser spiral illusion, using Fraser spiral inseparable graphic feature to design donation graphic.

6.3.1.1 The subject of attraction is represented by Herring illusion.

The main emotion of autism spectrum is fear, any small things in public place will cause any different degree of autistic children fear and everything around them is like a kaleidoscope. Their senses (vision, hearing, touch, smell, and taste) get too much information from the surrounding environment.

Using Herring illusion to represent three points of focus in the picture. The child's thoughts in the center of the picture are drawn into the gradually spreading concentric circles and then merge into the center point of the Herring illusion. This indicates that any small event in public place will cause autism spectrum to have different levels of fear and distraction. (*Image No.1*) (*Image No.2*)

[47] Doron, H. & Sharabany, A. (2013). Marital Patterns among Parents to Autistic Children. Psychology, 4, 445-453.

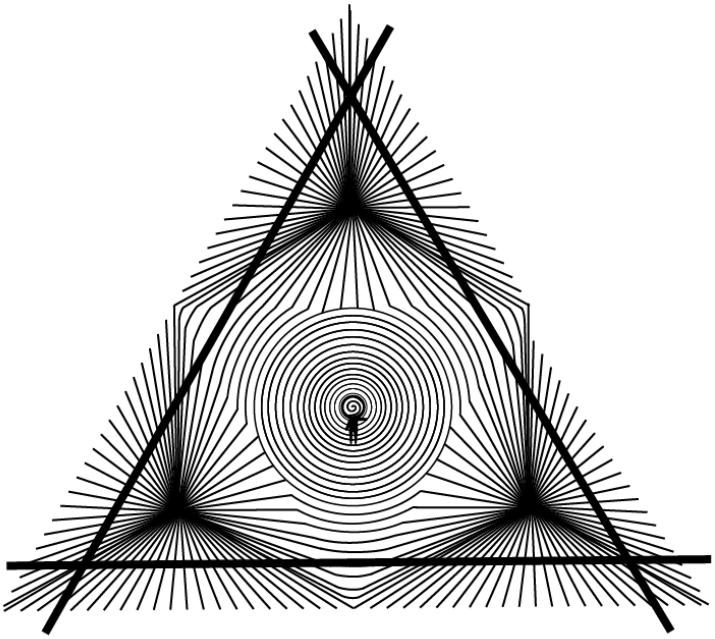


Image No.1

Image No.1 Image No.2

Explanation：Herring illusion to represent three points of focus in the picture. The child's thoughts in the center of the picture are drawn into the gradually spreading concentric circles and then merge into the center point of the Herring illusion.

Image No.2

Be designed by Haoran Li

6.3.1.2 The subject of emphasis is represented by Necker cube illusion.

Combining maze form with Necker cube illusion, meanwhile, using color matching and maze construction to form a brain-like morphology. This graphic is designed to express the complexity and confusion of the external world in the perception of autism spectrum. Due to the extreme sensitivity autism spectrum, their senses (vision, hearing, touch, smell, and taste) get too much information from the surrounding environment and can easily cause them to panic. The world is like this maze in their brains. (*Image No.3*) (*Image No.4*)

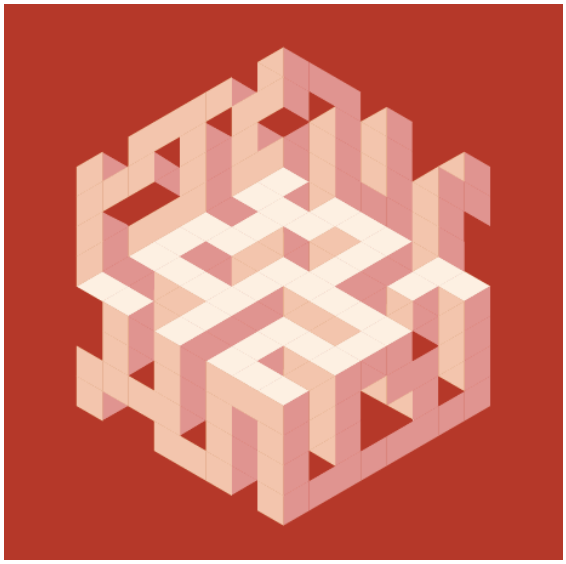


Image No.3

Image No.4

Image No.3　Image No.4

Explanation：Combining maze form with Necker cube illusion, meanwhile, using color matching and maze construction to form a brain-like morphology. This graphic is designed to express the complexity and confusion of the external world in the perception of autism spectrum.

6.3.1.3 The subject of popularization represented by Herman grid illusion.

At the center, the blur and uncertainty of the Herman grid illusion are shown in an exaggerated form with a magnified effect, in order to express autism spectrum 's sense of tension due to ambiguity and uncertainty. Because the strong light and overwhelming noise in public place will give this feeling to autism spectrum, it will cause them to be extremely uneasy, so that the sensory overload will cause restlessness. (*Image No.5*) (*Image No.6*)

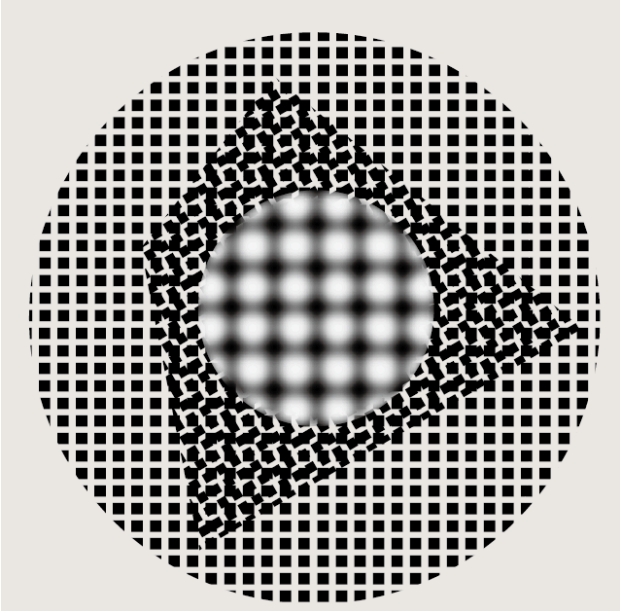


Image No.5

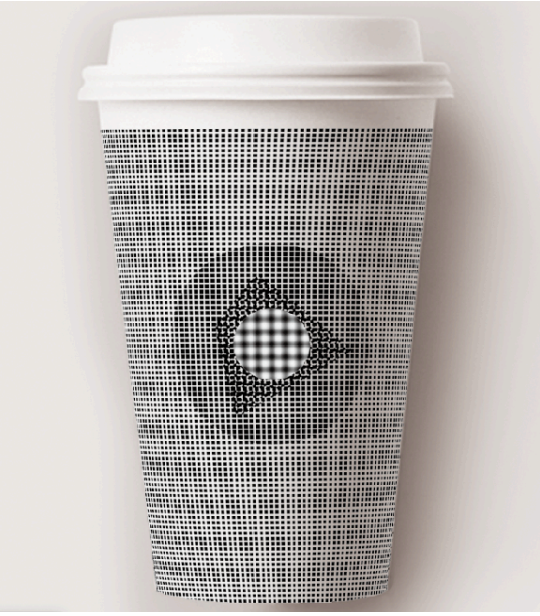


Image No.6

Image No.5 Image No.6

Explanation **:** Herman grid illusion are shown in an exaggerated form with a magnified effect, in order to express autism spectrum 's sense of tension due to ambiguity and uncertainty.

6.3.1.4 The subject of implementation is represented by Negative space illusion.

Eighty-five percent of autism is prone to gastro-intestinal problems during childhood or adolescence, and most of them cause intestinal dysbiosis due to the imbalance between good and bad bacteria. This will cause their discomfort and lead to instability. We should treat their diet specifically, such as gluten-free and casein-free diet. Therefore, we should take care of their stomachs with foods suitable for people with autism. This will make them more stable and reduce anxiety. Therefore, it is hoped that people will pay attention to the diet of people with autism and hope that the restaurant can make a special MENU for people with autism.

We should treat the diet of autistic children specifically because of their particular gastrointestinal problems. This design uses different dishes colors to distinguish the particularity of the autistic diet. Negative illusion combines orange flesh and "diet therapy", combining fork and "autism", indicating that dietary care should be strengthened for people with autism, so that their inner peace and reduce phobia. (*Image No.7*) (*Image No.8*)

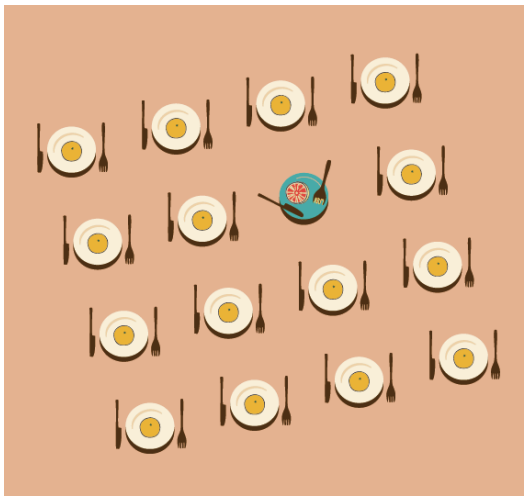


Image No.7

Image No.8

Image No.7 Image No.8

Explanation：Negative illusion combines orange flesh and "diet therapy", combining fork and "autism", indicating that dietary care should be strengthened for people with autism, so that their inner peace and reduce phobia.

6.3.1.5 The subject of appeal is represented by Fraser spiral illusion.

Fraser spiral does not create visual illusions if it breaks，just like the autism spectrum is due to neurodevelopment disorder so they rarely have normal cognitive models. Therefore, people's repair of Fraser spiral illusion conveys the attitude toward autism spectrum, that is, they are caring for them through the power of unity. This design appeals to raise funds around the world to provide better living condition and facilities for the autism spectrum. (*Image No.9*)

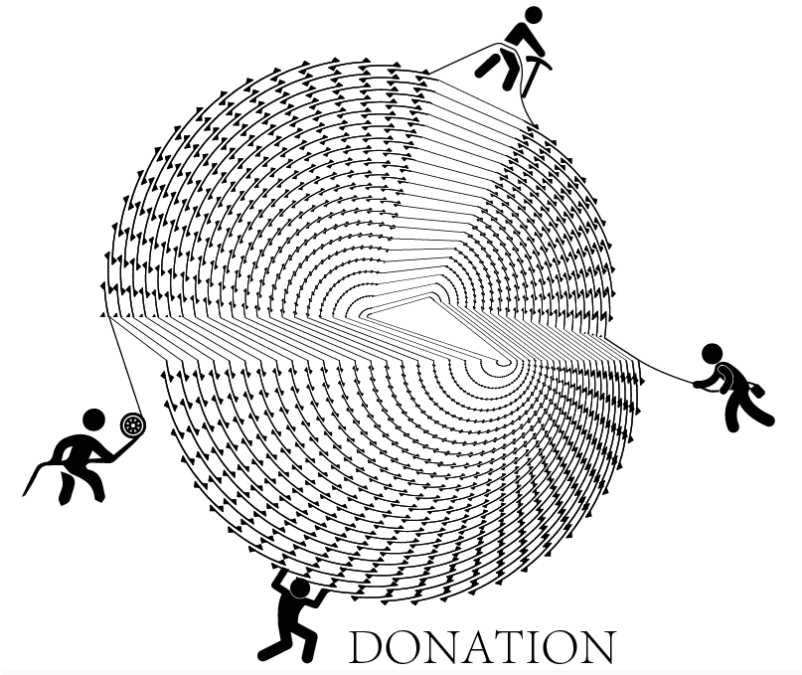


Image No.9

Image No.9

Explanation：Negative illusion combines orange flesh and "diet therapy", combining fork and "autism", indicating that dietary care should be strengthened for people with autism, so that their inner peace and reduce phobia.

7. Conclusion

Optical illusion refers to the fact that what the eye sees is not true, thus, the project through optical illusion to convey a phenomenon that you see children with autism are normal, but only the eyes to see. In fact, they have different levels of capacity loss, therefore, we must pay attention to them through appearances. To increase ordinary people's understanding and respect for autism spectrum and reduce the mismatch between autism spectrum ability and the environment. Meanwhile, in the process of graphic design combined with the autism spectrum, there are many aspects of extreme design that can be done for children with autism，and will continue to be designed to fit their own characteristics. Later, I will also pay more attention to inclusive design, not just focus on universal design.

Referance

1---Arnheim R, (2004) Art and Visual Perception: A Psychology of the Creative Eye. Berkeley: University of California Press

2---Bulatov A, Bertulis A, Mickiene L, (1997) "Geometrical illusions: study and modelling" Biological Cybernetics 77 395–406

3---Chiang C A, (1968) "A new theory to explain geometrical illusions by crossing lines" Perception & Psychophysics 3 174–176

4---Coren S, Girgus J, Erlichman H, Hakstian A R, (1976) "An empirical taxonomy of visual illusions" Perception & Psychophysics 20 129–137

5---Capra, F., Luisi, P. L. (2014). The systems view of life : a unifying vision. Cambridge, UK: MPG Printgroup Ltd.11.

6---Dewar R E, (1967) "Stimulus determinations of the magnitude of the Müller-Lyer illusion" Perception and Motor Skills 24 708–710

7---Day R H, Dickson R G, (1976) "Apparent length of the arms of acute and obtuse angles and the components of the Müller-Lyer illusion" Australian Journal of Psychology 28 137–148

8---Davies T N, Spencer J, (1977) "An explanation for the Müller-Lyer illusion" Perception and Motor Skills 45 219–224

9---Douglas R. Hofstadter, (1999) "Gödel, Escher, Bach: an Eternal Golden Braid". New York: Basic Books.

10--- Doron, H. & Sharabany, A. (2013). Marital Patterns among Parents to Autistic Children. Psychology, 4, 445-453.

11---Eriksson E S, (1967) "Field effects and two-dimensional form perception" Scandinavian Journal of Psychology 8 218– 242

12---Erlebacher A, Sekuler R, (1974) "Perceived length depends on exposure duration: Straight lines and Müller-Lyer stimuli" Journal of Experimental Psychology 103 724–728

13---Eriksson E S, (1970) "A eld theory of visual illusions" British Journal of Psychology 61 451–456

14--- "F84. Pervasive developmental disorders". ICD-10: International Statistical Classification of Diseases and Related Health Problems: Tenth Revision. World Health Organization. (2007). Archived from the original on 21 April 2013. Retrieved 10 October 2009.

15--- Ganz L, (1966) “Mechanisms of the gural aftereffects” Psychological Review 73 128–150

16---Girgus J S, Coren S, Agdern M, (1972) “The interrelationship between the Ebbinghaus and Delbœuf illusions” Journal of Experimental Psychology 95 453–455

17---Gregory R L, (1974) Concepts and Mechanisms of Perception (London: Duckworth)

18---Gregory R L, (1978) Eyes and Brain: The Psychology of Seeing 3rd edition (New York: McGraw-Hill)

19---Goto T, (1992) “Functional representation of visual illusions by use of various stimulus-presenting conditions” International Journal of Psychology 27 31–32

20---Goto T, Uchiyama I, Imai A, Takahashi S, Hanari T, Nakamura S, Kobari H, (2007) “Assimilation and contrast in optical illusions” Japanese Psychological Research 49 33–44

21---Geschwind DH (2008). "Autism: many genes, common pathways?". Cell. 135 (3): 391–5.

22---GBD 2015 Disease and Injury Incidence and Prevalence, Collaborators. (8 October 2016). "Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015". Lancet. 388 (10053): 1545–1602.

23---Hamburger K, Hasen T, Gegenfurtner K R, (2007) “Geometric-optical illusions at isoluminance” Vision Research 47 3276–3285

24--Hachen M,(2007) Scienza della visione. Spazio e Gestalt, design e comunicaizone.Milan:Apogeo Education

25---Judd C H, (1902) “Practice and its effects on the geometric illusions” Psychological Review 9 27–39

26---Johnson CP, Myers SM (2007). "Identification and evaluation of children with autism spectrum disorders". Pediatrics. 120 (5): 1183–215.

27---Kanizsa G, (1997) Grammatica del vedere. Saggi su percezione e Gestalt.Bologna

28---Massaro D W, Anderson N H, (1971) “Judgmental model of the Ebbinghaus illusion” Journal of Experimental Psychology 89 147–151

29---Marr, D. (1982). Vision: A Computational Investigation into the Human Representation and Processing of Visual Information. W. H. Freeman.

30--- Mayes, S.D. and Calhoun, S.L. (2003) Ability Profiles in Children with Autism: Influenced of Age and IQ. Autism, 7, 65-80.

31--- Myers SM, Johnson CP (2007). "Management of children with autism spectrum disorders". Pediatrics. 120 (5): 1162–82.

32--- Mayes, SD, Calhoun, SL, Aggarwal, R., Baker, C., Mathapati, S., Molitoris, S., & Mayes, RD (2013). Unusual fears in children with autism. Research in Autism Spectrum Disorders , 7 , 151–158.

33--- Ninio J, (1979) "An algorithm that generates a large number of geometric visual illusions" Journal of Theoretical Biology 79 167–201

34---Oyama T, (1962) "The effect of hue and brightness on the size-illusion of concentric circles" American Journal of Psychology 75 45–55

35--- Ozand, P.T., Al-Odaib, A., Merza, H. and Al Harbi, S. (2003) Autism: A Review. Journal of Pediatric Neurology, 1, 55-67.

36--- Pressey A W, Murray R, (1976) "Further developments in the assimilation theory of geometrical illusions: the adjacency principle" Perception & Psychophysics 19 536–544

37---Restle F, Merryman C, (1969) "Distance and an illusion of length of line" Journal of Experimental Psychology 81 297– 302

38---Restle F, (1971) "Visual illusions", in Adaptation Level Theory Ed. Appley M H (New York: Academic Press)

39---Restle F, (1977) "Assimilation produced by contrast", in Cognitive Theory volume 3, Eds Castellan N J, Restle F (Hillsdale, NJ: Lawrence Erlbaum Associates)

40---Roberts B, Harris M G, Yates T A, (2005) "The roles of inducer size and distance in the Ebbinghaus illusion (Titchener circles)" Perception 34 847–856

41---Schiano D J, (1986) "Relative size and spatial separation: effects on the parallel-lines illusion" Perception and Motor Skills 63 1151–1155

42--- Silverman C (2008). "Fieldwork on another planet: social science perspectives on the autism spectrum". BioSocieties. 3 (3): 325–41.

43--- Tagliasco V, Vincenzi A, Boringhieri B, (1998) Dietro le formule: I discorsi della logica e della matematica (Comunicazione e linguaggio) . Milan

44---Williams, Robert. (1979)The Geometrical Foundation of Natural Structure: A Source Book of Design. Dover Publications.

45---Westheimer G, Wehrhahn C (1997). "Real and virtual borders in the Poggendorff illusion". Perception. 26 (12): 1495–501.

46---Zöllner F (1860). "Ueber eine neue Art von Pseudoskopie und ihre Beziehungen zu den von Plateau und Oppel beschriebenen Bewegungsphaenomenen". Annalen der Physik. 186 (7): 500–25.

47--- Autism Spectrum Disorder, 299.00 (F84.0). (2013) In: American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. American Psychiatric Publishing.