WHAT COGNITIVE NEUROSCIENCE SAY ABOUT AESTHETIC EXPERIENCE?*

SERAY KANTARCIOĞLU, ENVER GÜNER*****

ABSTRACT

Today, researchers can observe the neural responses to an aesthetic image in the human brain and examine the physiological reactions of viewers to an art object. Neuroaesthetics is a new field of study that characterizes the evolutionary history of the creation and evaluation of art by examining these responses. Neuroscientists, who have managed to map the neural pathways of the visual processing processes that occur in a person's brain while watching artworks, have been focusing on how the visual cortex processes information and reaches aesthetic judgment in recent years.

The focus of this research is how a work of art is perceived, how the visual cortex processes information when reaching aesthetic judgments, color perception, synesthesia, and finally, the effects of brain damage on artists.

In the study, firstly, the visual-spatial processes, which are the basic processes of visual perception, were discussed. In this way, object perception and the visual processes occurring in the brain during the perception of the art object were examined. In the next section, which draws attention to the perception of color as well as shape and spatial location, synesthesia, which has been the subject of many studies by neuroscientists in recent years and is known as the perception of one sense together with another sense, is discussed. Finally, studies on brain-damaged artists, one of the experimental methods most preferred by neuroscientists in research on aesthetic perception, and the data obtained from these studies are presented.

Keywords: Neuroaesthetic, Empirical aesthetic, Visual perception, Color, Synesthesia.

* This article is produced from a Ph.D. thesis named "Perception of Artwork and Visual Processes from Neuroaesthetic Perspective" by Seray Kantarcıoğlu.

** PhD., Akdeniz University, Institute of Fine Arts, Department of Art and Design, tokseray@gmail.com, https://orcid.org/0000-0001-9385-3499.

*** Asst. Prof., Akdeniz University, Fine Arts Faculty, Department of Ceramic Design, eguner@akdeniz.edu.tr, https://orcid.org/0000-0002-8150-8839.

**** İki yazar da çalışmaya eşit oranında katkıda bulunmuşlardır. Çalışmada herhangi bir destek ve teşekkür beyanı veya çatışma beyanı yoktur.

Research Article, **Received:** 03.11.2023, **Accepted:** 12.06.2024, **DOI** 10.48069/akdenizsanat.1390910.

BİLİŞSEL SİNİRBİLİM ESTETİK DENEYİM HAKKINDA NE SÖYLÜYOR?*

SERAY KANTARCIOĞLU, ENVER GÜNER***

ÖZ

Günümüzde insan beyninde estetik görüntülere verilen nöral tepkilerin gözlemlenebilmesi ile izleyicilerin sanat nesnesi karşısında verdiği fizyolojik tepkiler incelenebilmektedir. Nöroestetik, bu tepkilerin incelenerek sanatın oluşturulması ve değerlendirilmesinin evrimsel geçmişini karakterize eden yeni bir çalışma alanıdır. Kişinin bir sanat eserini izlerken beyninde gerçekleşen görsel işlem süreçlerinin nöral yollarını haritalamayı başaran sinirbilimciler, son yıllarda görsel korteksin bilgiyi nasıl işlediği ve estetik yargıya nasıl ulaşıldığı üzerine odaklanmaktadırlar.

Bu araştırmanın odağını, sinirbilimcilere göre bir sanat eserinin nasıl algılandığı, estetik yargılara ulaşılırken görsel korteksin bilgiyi nasıl işlediği, renk algısı, sinestezi ve son olarak beyin hasarının sanatçılar üzerindeki etkileri oluşturmaktadır.

Çalışmada ilk olarak, görsel algının temel aşamaları olan görsel-uzaysal süreçler ele alınmıştır. Bu sayede nesne algılama ve sanat nesnesinin algılanması sırasında beyinde gerçekleşen nöral süreçler incelenmiştir. Biçimin ve uzamsal konumun yanı sıra renk algısına da dikkat çeken bir sonraki bölümde, son yıllarda sinirbilimciler tarafından pek çok çalışmaya konu olan ve bir duyunun başka bir duyu ile birlikte algılaması olarak bilinen sinestezi ele alınmıştır. Son olarak sinirbilimcilerin estetik deneyim üzerine yaptığı çalışmalarda en çok tercih ettiği deneysel yöntemlerden biri olan beyin hasarı yaşamış sanatçılar üzerinde yapılan çalışmalar ve bu araştırmalardan elde edilen verilere yer verilmiştir.

Anahtar Kelimeler: Nöroestetik, Ampirik estetik, Görsel algı, Renk, Sinestezi.

*Bu çalışma, Seray Kantarcıoğlu tarafından hazırlanan, ''Nöroestetik Perspektifinden Sanat Eseri Algısı ve Görsel İşlem Süreçleri'' başlıklı Sanatta Yeterlik Tezi'nden üretilmiştir.

** Doktora, Akdeniz Üniversitesi, Güzel Sanatlar Enstitüsü, Sanat ve Tasarım Bölümü, tokseray@gmail.com, https://orcid.org/0000-0001-9385-3499.

*** Dr. Öğr. Üyesi, Akdeniz Üniversitesi, Güzel Sanatlar Fakültesi, Seramik Bölümü, eguner@akdeniz.edu.tr, https://orcid.org/0000-0002-8150-8839.

Araştırma Makalesi, **Makale Gönderim:** 14.11.2023, **Makale Kabul:** 12.06.2024, **DOI** 10.48069/akdenizsanat.1390910.

1. INTRODUCTION

It is well known that the origins of studies on the relationship between the mind's potential for aesthetic perception and its biological origins date back to the late 19th century. The beginning of psychological aesthetics is considered to the publication of Vorschule der Aesthetik by Gustav Fetchner in 1876, the founder of empirical aesthetics. A psychophysicist, Fechner believed that there was a connection between the physical properties of stimuli and the sensations they produced. According to Fetchner, external psychophysics involved the relationship between variations in the physical properties of stimuli and the sensations they caused, while internal psychophysics involved the relationship between these sensations and the neural activities underlying them. In this sense, Fechner was truly ahead of his time in anticipating one of the main goals of modern neuroscience, which involves establishing correspondences between neural and mental processes. Recent developments in cognitive neuroscience have made possible the research opportunities that Fechner envisaged over a century ago.

Neuroaesthetics is an interdisciplinary field that studies the cognitive processes underlying aesthetic experience. It focuses on how works of art are perceived and the mechanisms by which they are processed in the brain. The field was first established in the late 20th century by neuroscientists Semir Zeki and Vilayanur Subramanian Ramachandran and explores how the brain processes and responds to artworks, combining perspectives from neuroscience, art, philosophy, and evolutionary psychology.

It is only in the last 50 years that technologies have been developed to monitor what is going on in the brain. This has allowed scientists to observe the neural processes that take place while artists create their works or viewers look at them. With these scientific researches, neuroaesthetics adds new principles to visual perception known as Gestalt principles and places them in an evolutionary context. Scientists are also contributing to new theories about why art is so prevalent in all cultures. Since the 2000s, many experimental studies of the creative brain and art theory have provided important data on how the brain evaluates artworks and how this processing contributes to our general perception of beauty and art.

This study aims to present the current theories and perspectives on aesthetic experience by utilizing the latest experimental data derived from neuroscience. To achieve this goal, both quantitative and qualitative data regarding human aesthetic perception have been used in different sections.

The theoretical framework of the research has been carefully crafted by reviewing contemporary scientific approaches to aesthetic experience and the neuroaesthetic literature. In this context, recent advancements, such as the information processing model during the perception of artworks proposed by neuroaesthetic and Semir Zeki's discovery of the color-sensitive v4 region in the brain, have been presented to the reader through neuroimaging results and clinical experimental data spanning the last two decades.

Using the document analysis method, the study introduces new perspectives of veiwer-centered aesthetic perception approaches while addressing cognitive processes related to aesthetic perception within a scientific context. The research holds importance in succinctly conveying the processes of formal perception of artworks and making aesthetic judgments, and it contributes new information to empirical aesthetic research further studies.

2. VISUO-SPATIAL PROCESSES

The brain's ability to make and appreciate art is directly related to the ability to see. The recognition, perception, viewing and interpretation of the art object are perceptual processes that take place one after the other and in parallel. Therefore, in order to understand the roots of our ability to appreciate art, we must first understand the visual information processing system. Scientific studies presenting data on art perception from the perspective of neuroscience show that we perceive works of art in stages, just as the information processing model in the visual system is progressive. In order to understand these stages, we must first look at the visual-spatial perception processes.

Spatial perception is essential for an organism to adapt to its surroundings and survive. The organism reacts to the resources it requires to continue its life by recognizing both its own and the other living and nonliving things' spatial position in space. It also responds to stimuli that risk its survival. People perceive space based on; the placement of objects in space, the relationships between events and objects in space, the interactions between bodily parts, and the relationships between the body and objects (Mountcastle, 2000).

The visual system, which gives numerous cues about the surroundings, is critical in spatial perception. Apart from the perception of physical aspects such as color and shape of distant objects, the sense of sight also enables the perceiving of movement. By detecting the position of items and measuring the distance between objects, visual systems allow for the perception of an object with missing physical parts in their fullness (Karakaş, 2008, p. 188).

Perception of an object's characteristics and perception of object' spatial location are two functions which are closely connected. Nevertheless, in the brain, these two modes of perception operate separately but in parallel and synchronously. The primate visual system includes two functional pathways that control object perception and visuospatial perception. The ventral (occipitotemporal) and dorsal (occipitoparietal) pathways are often known as the "what" and "where" pathways (Mishkin, 1983).

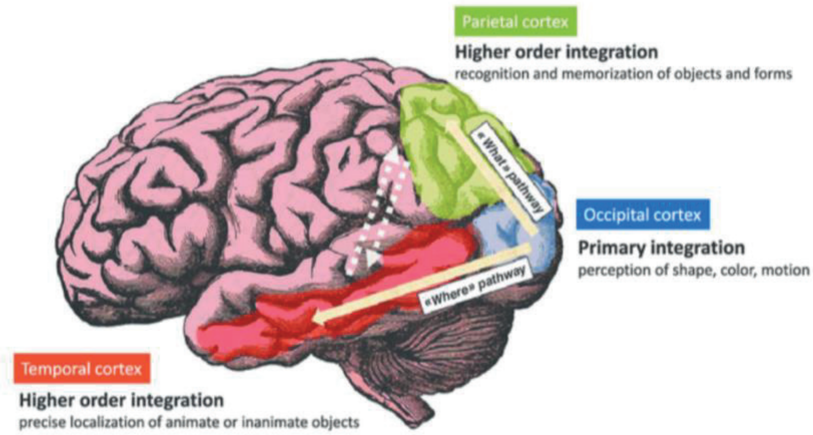

Figure 1: Visual pathways in the brain.

Source:Nataf S. (2016). Clonal Selection vs Clonal Cooperation: The Integrated Perception of Immune Objects, p. 2226.

Both pathways originate from the primary occipital cortex. Goodale's research indicates that the ventral pathway is crucial for recognizing object features, whereas the dorsal pathway is important for perceiving relationships between the parts of an object, the object's location, and visuomotor actions towards objects (Goodale, 2000).

Andersen (1997), on the other hand reveals that neurons in the ventral areas respond to object features such as shape, color, and context, while neurons in the dorsal and middle temporal areas respond to visual-spatial attributes and visually-guided movements without responding to specific object features.

Clearly, the dorsal pathway is concerned with "where" the object is, whereas the ventral pathway is concerned with "what" the object is. However, in daily life, object and place perceptions are evaluated as a whole.

So, beyond object perception, how is a work of art perceived from the perspective of neuroscience?

An experimental research programme in visual neuroaesthetics is known to be based on two principles. The first principle is that visual aesthetics, like vision, has multiple components. The second is that aesthetic experiences emerge from the combination of responses to these different components. The process of human visual recognition of objects provides a framework for considering these components. Currently, research focuses on these components and their properties in various combinations.

Visual information is processed by the nervous system in a hierarchical and parallel manner. In the visual system, our perception undergoes multiple stages of processing, namely early, intermediate, and late vision. Early vision involves extracting fundamental elements from the visual stimuli, such as color, brightness, form, motion, and location. These basic features are then processed in different brain regions. Intermediate vision comes into play, organizing certain visual elements into coherent groups while separating others, which aids in comprehending the complex visual input. Late vision takes charge of selecting relevant coherent areas to focus on and activates memory to recognize objects and attribute meanings to them (Chatterjee 2003a, Farah 2000).

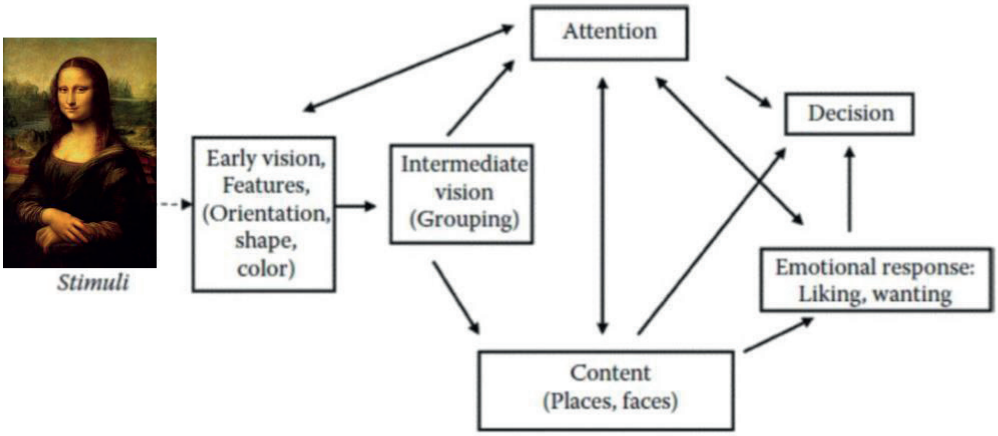

Figure 2: A General Information Processing Model In Neuroaesthetic Research.

Source: Gottfried J. A. (ed.), (2011). Neurobiology of Emotion and Reward, Boca Raton (FL): CRC Press.

When it comes to visual artwork, it can also be analyzed based on early, intermediate, and late components. Studies have demonstrated that aesthetic perception can discern the form and content of artworks. Early and intermediate vision processes play a vital role in perceiving and interpreting the shapes and visual structures present in the artwork, while later vision processes are more concerned with understanding its content and significance. Typically, when viewing an artwork, the initial visual elements perceived are its colors and spatial arrangement, which are then combined to form larger perceptual units. This process of grouping contributes to the overall compositional balance of the artwork, often referred to as "unity in variety" (Ishai, Fairhall and Pepperell, 2007).

Due to the data obtained by Chatterjee over the past decade, the brain mapping of emotional responses to an aesthetic image beyond perception is now able to be monitored and it is possible to observe how aesthetic judgements are made (Chatterjee, 2011, p. 23).

> Aesthetic judgements about stimuli, as measured by preference ratings, are likely to engage widely distributed circuits in the dorsolateral frontal and medial frontal cortices. The general point is that visual neuroaesthetics, like most complex biological systems, is hierarchical and can be decomposed into its component subsystems. It is precisely this hierarchical organization that makes empirical aesthetics possible (Simon, 1962).

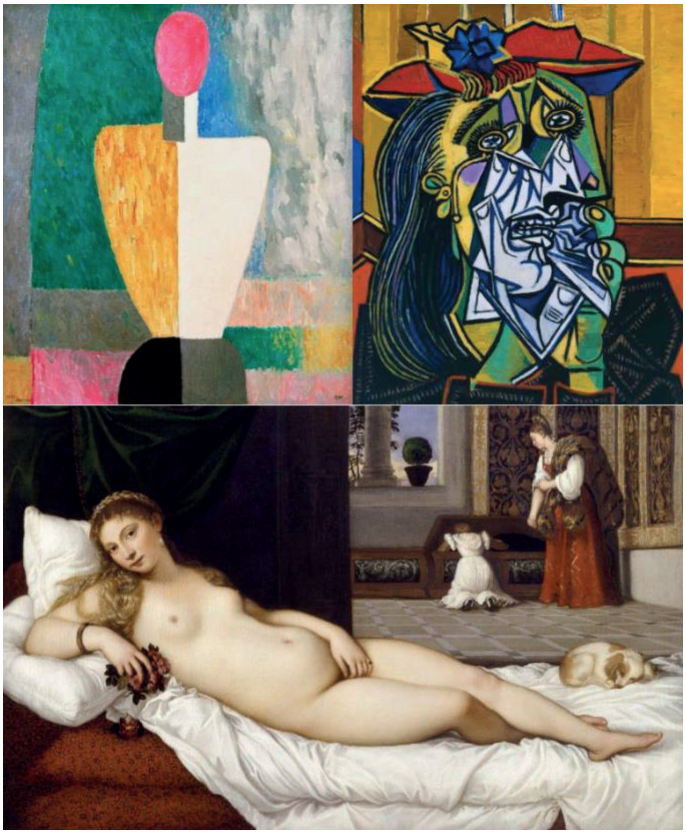

Figure 3: Hierarchical progression in visual aesthetics, exemplifying visual processing through the brushstroke of three famous artists. Each painting depicts the female figure through successive levels of representational complexity, from Malevich (early) to Picasso (middle) to Titian (late).

(a) Torso, 1928-32 (oil on canvas), Kazimir Severinovich Malevich (1878-1935)

(b) Weeping Woman, 1937 (oil on canvas), Pablo Picasso (1881-1973)

(c) Venus of Urbino, 1538 (oil on canvas) Titian (Tiziano Vecellio), (1488-1576)

Source: Gottfried J. A. (ed.), (2011). Neurobiology of Emotion and Reward, Boca Raton (FL): CRC Press, p. 436.

The concepts of "perception" and "cognition" are highly significant in understanding the gradual mental processes that unfold when experiencing works of art in aesthetic perception. Perception is the process of acquiring information from environmental stimuli through visual, auditory, tactile, and other sensory interventions. In neuroscience research, the concept of art perception generally focuses on the sensory experience of artworks. The perception of visual elements such as colors, shapes, textures, and compositions forms the foundation of the aesthetic experience, as artworks primarily rely on these initially processed sensory inputs.

On the other hand, cognition involves mental processes such as understanding and thinking. In aesthetic perception, the concept of cognition represents a cognitive process of interpreting and evaluating works of art. Through cognitive abilities used to understand the theme of the artwork, decipher the artist's intentions, and grasp the overall message of the piece, individuals arrive at an aesthetic judgment after evaluating the art object. In recent years, neuroaesthetic research has reached a consensus among scientists that the human tendency to appreciate art has its origins in the development of the prefrontal cortex and is related to the brain's reward mechanisms. Professor Ann Marie Barry emphasizes the role of these mechanisms by saying:

> What all aesthetic theories commonly share is the idea that the pleasure derived from images (regardless of the type) is obtained through the senses and leads to a sense of euphoria. Appreciating aesthetics typically culminates in a feeling of satisfaction. This feeling is the result of a series of cognitive processes. The convergence of everything into a unified concept through obtaining visual meaning from visual inputs results in aesthetic pleasure, often driven by problem-solving (Barry, 2016, p. 148).

Another theory put forth by neuroscientists focuses particularly on the role of mirror neurons in the cognitive processes of perceiving and understanding art. Scientists support this theory by proposing the theory of empathic response to art, which is based on the interaction between two elements. According to this approach, the perception of art involves the simulation of actions, emotions, and bodily sensations associated with the activation of mirror neurons.

The relationship between empathic emotions triggered by neural simulation in the art viewer and the content of the artwork constitutes the fundamental element of empathic response to art. The second crucial aspect is the relationship between the empathic feelings of the art viewer and the artistic production technique (brush strokes, texture, etc.). This theory suggests that it will form the fundamental framework for the aesthetic appreciation response to art not only for artistic performances (live/recorded or moving) but also for static aesthetic forms, such as visual arts (Gallese, 2013, p. 449).

3. COLOR PERCEPTION

Color perception is a complex trait that plays a critical role in how humans interact with their environment. Throughout evolution, color has helped humans develop the ability to survive and interact with their environment. Looking at its evolutionary origins, color perception is linked to basic survival strategies in nature, such as protecting against danger, finding food, mates, and communication.

The importance of color in visual perception is not limited to survival; it is also critical to communication and social interaction. Emotional expressions between people are communicated through color. For example, the color red symbolizes danger or passion, while the color blue can evoke feelings of calm and serenity. These colors are used to express emotional states and communicate those feelings to others.

The visual arts have embraced and developed the use of color as a means of expression and meaning. The contribution of color to the aesthetic experience is an important element that enhances the emotion, meaning, and atmosphere of artworks. In selecting and using color palettes, artists make deliberate choices to evoke a particular emotional response in the viewer, to create a particular atmosphere, or to tell a story. Especially in paintings, the use of color becomes a central element of the composition. Certain combinations of colors can lead the viewer to a particular emotional state. Cool tones (blues, greens) can evoke a sense of peace and serenity in a painting, while warm colors (reds, yellows) can represent energy and passion. The symbolism of colors is also common in works of art. A color can have different meanings depending on the culture. For example, while white symbolizes purity and innocence in Western cultures, it can be associated with death and mourning in Eastern cultures. This symbolism adds depth and layered meanings to artworks.

The latest discovery that neuroscience has brought to a wide range of topics, from the evolutionary origins of the use of color in the visual arts to its symbolic meanings, is the discovery of the color-sensitive v4 region in the brain by Semir Zeki, one of the founders of neuroesthetics. Zeki conducted many experiments on the activation of this region and added new information to the literature that will shed light on the neural mechanisms of color perception in humans.

Color is the product of a complicated process carried out by the brain, which consists mainly of comparing the wavelength composition of light reflected from a surface with the wavelength composition of light reflected from surrounding surfaces. According to physiological and clinical research, the human brain divides color processing into three general cortical stages: V1, V2, and V4. The perception of the existence and intensity of various wavelengths as well as the identification of the wavelength difference are the primary goals of the first stage of color processing, which is based on V1 and possibly V2. The automated mechanisms of color constancy without consideration of memory, judgment, or learning are the focus of the second stage, which is based on V4. The tendency of objects to appear in the same color under different lighting conditions is known as color constancy. The third stage is primarily focused on object colors and is based on the temporal and frontal cortex (Zeki, 1999).

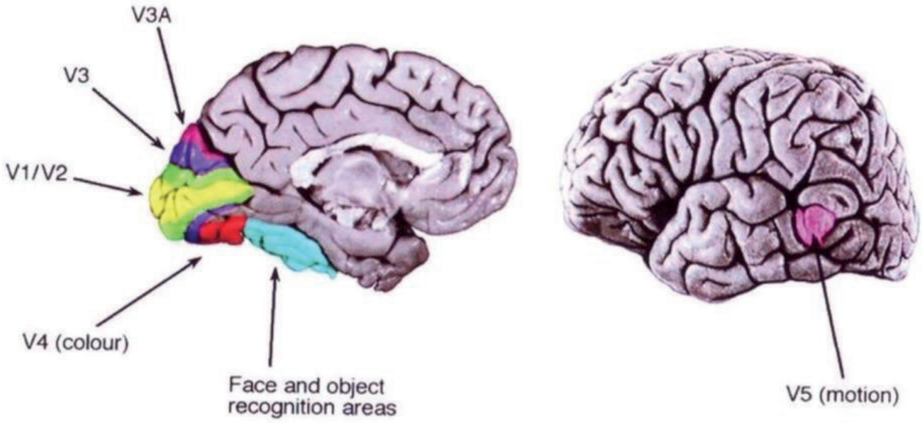

Figure 4: Functional Organization of The Human Visual Cortex (Occipital Lobe)

Source: Zeki, S. (1999). Inner Vision: An Exploration of Art and the Brain. Oxford University Press.

Ramachandran also explains that the V4 region is responsible for processing visual information related to color perception. The process begins with neural signals from the retina reaching the back of the brain, where the incoming image is categorized based on its fundamental attributes like color, motion, shape, and depth. After this initial classification, information about these different features is separated and distributed to various areas within the temporal and parietal lobes. For instance, details about the direction of moving objects are sent to the V5 area in the parietal lobes, which is specialized in motion processing. In contrast, color information is predominantly directed to the V4 area. Additionally, the processed color information within the V4 area can further be transmitted to remote regions of the temporal lobes, close to the angular gyrus (Ramachandran, 2011, p. 136).

Semir Zeki's color perception research includes not just the perception of object colors but also brain distinctions in the perception of compositions generated by colored geometric patterns. In this connection, Zeki conducted tests with Mondrian paintings as stimuli in 1997, and in 1998, he reported the contrasts and similarities between color perception and the brain dynamics created by Mondrian paintings alongside Ludovica Marini. Zeki utilized fMRI to identify color pathways in the human brain beyond the main visual cortex's region V4.
He asked volunteers to see objects in natural and non-natural colors, as well as their achromatic equivalents, and then compared the activity produced in the brain under different conditions. The findings revealed that both naturally and artificially colored items engaged a route from V1 to V4, but this activity did not entirely match that caused by viewing abstract Mondrian paintings. According to the results of the experiment:

> Normally coloured objects activated more anterior parts of the fusiform gyrus, hippocampus and the ventrolateral frontal cortex, whereas abnormally coloured objects activated the dorsolateral frontal cortex (Zeki, 1998).

Figure 5: Objects in natural and non-natural colours used by Zeki as stimuli

Source: Zeki S. (1998). Three cortical stages of color processing in the human brain, Brain, p.121.

Another study, conducted by Osaka, has provided significant data in recent times regarding color perception. In the research, a series of experiments were conducted to understand how monochromatic, harmonious, and multicolored images are evaluated within certain mechanisms and how colors are remembered, harmonized, and appreciated in the brain. Osaka's work on color perception shows color is a visual stimulus that is represented by the brain either verbally or visually. There is little variation in the activation patterns of verbal representations between identical hues and corresponding color descriptions. Osaka's data on harmony and aesthetic preferences have contributed not only to studies on color, but also to the general field of neuroaesthetics by showing how reward mechanisms are linked to visual perception (Osaka, 2022, p. 635).

As a result, color exists only in our own neurological system and nowhere else in the cosmos. Color is a perceptual process that occurs in our nerves, not a universal attribute or quality of the physical world. According to neuroaesthetic researchers, our nervous system evolved specific sensory cells that enable our brain to sense color, since information supplied by chosen reflections of a restricted band of electromagnetic radiation is beneficial to humans in an evolutionary context. However, this perceptual process may not work in the same way for everyone. Synesthesia is an exceptional phenomenon in which the perception of color is mixed with other sensory perceptions, and it contains very interesting examples in terms of its relationship to artistic creativity.

3.1. SYNESTHESIA

In the nineteenth century, Francis Galton, Charles Darwin's cousin, found that some apparently totally normal members of the general public perceived numerals in color. Five were blue, seven were yellow, eight were pale green, and nine were indigo. Notes resembled colors for some persons who were otherwise fully normal. C sharp may be blue, F sharp could be green, and another note could be yellow. Synesthesia is a condition in which some sensations get confused. While typical people perceive all of their senses independently, synesthetic persons experience some sensations together. What causes this to happen?

Ramachandran addresses this question from two perspectives, and emphasizes that one of the answers is very interesting:

> As Sir Galton said in the 1800s, synesthesia runs in families and is therefore genetically based. The second is that synesthesia is also related to creativity. Synesthesia is 8 times more common in artists, poets, novelists and other creative people in society than in the general population (Ramachandran, 2007).

The color and number areas of the brain are known to be adjacent in the brain. Because of that, there may be unintentional linkages between the color and number zones. As a result, whenever people have seen a number, they also perceive the corresponding color. The presence of an aberrant gene in the family or a mutation in the gene that generates cross-links is cited as the primary cause of synesthesia. It appears that when we are born, there is an extensive network of connections between all regions of our brain. However, as we grow, these connections are selectively reduced, leading to the distinct modular structure of the mature brain. If a specific gene responsible for this reduction undergoes a mutation, the trimming process between adjacent brain areas becomes deficient. This deficiency can result in various forms of synesthesia, such as associating numbers with colors or tones with colors.

So, what do artists, poets, and novelists have in common? They possess the ability to link seemingly unrelated ideas or thoughts metaphorically. For instance, when someone says "Juliet is the sun," they aren't suggesting that she is literally a glowing ball of fire. Instead, they are making a connection between her warmth, radiance, and life-giving nature, similar to the sun. This ability to establish connections is crucial in their creative pursuits. If we assume that individuals with synesthesia have a greater number of cross-connections and associations between different parts of their brain, it follows that they would exhibit a higher propensity for metaphorical thinking and creativity. Consequently, the prevalence of synesthesia is eight times higher among poets, artists, and novelists (Ramachandran, 2007).

Research indicates that every individual possesses the capacity for synesthetic abstraction, as demonstrated in the Kiki and Buba experiment. This experiment, initially conducted by Wolfgang Köhler in 1929 and later repeated by Vilayanur Ramachandran in 2001, involved participants determining which of two shapes, shown below, represented Kiki and Buba. In Ramachandran's study, 99 percent of the audience identified the right shape as Kiki and the left shape as Buba. This outcome holds significant implications.

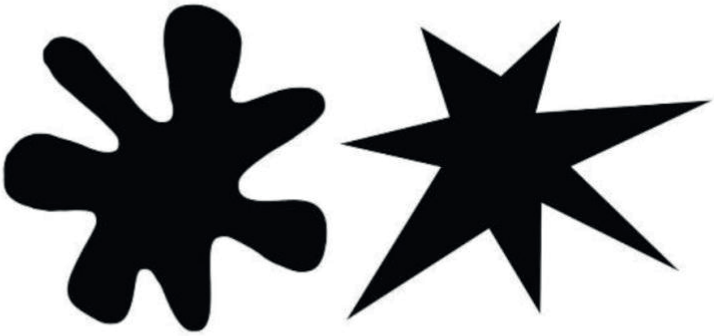

Figure 6: Buba (left), Kiki (right)

Source: Xochitl G. (2016). Media guide: The Bouba-Kiki Effect, Science Friday. https://www.sciencefriday.com/educational-resources/media-guide-the-bouba-kiki-effect

In reality, engaging in synesthetic abstraction through the cross pattern involves a sudden change in auditory tone in the brain's auditory cortex. The term “Ki-ki” represents the excitation of hair cells in response to the sharpness inherent in the angular shape. This reveals that the brain is making connections on a fundamental level. The photons received by the eyes contribute to the perception of shape, while the hair cells in the ear contribute to the auditory pattern. Nevertheless, the human brain has the remarkable ability to extract common elements. This primitive form of abstraction occurs in a specific brain region known as the fusiform gyrus. When this area is damaged, individuals not only lose the capacity to establish the Buba-Kiki connection but also struggle with metaphorical associations (Ramachandran, 2007).

4. STUDIES ON BRAIN INJURY ON ARTISTS

In Neuroaesthetics, there are various research methods aimed to understand the functions of the human brain. For instance, Functional Magnetic Resonance Imaging (fMRI) allows researchers to measure brain activity and observe how individuals respond to specific visual stimuli or artworks, as well as identify the activated brain regions. Other notable methods include Transcranial Magnetic Stimulation (TMS), Electroencephalography (EEG), Eye Movement Tracking, Galvanic Skin Response tests, and Behavioral Experiments. Among these methods, studying artists who have sustained permanent damage to specific brain regions[1] provides valuable insights.

In such cases, genetic alterations in these brain areas do not necessarily lead to a complete loss of mental capacity; rather, they often result in altered perception abilities. However, it's

[1]The cases discussed here are conveyed to the reader in the same words as neuroscientists have identified the patient's condition. The common point of physiological conditions such as head trauma, paralysis, stroke, cerebral hemorrhage experienced by artists is that all of them have experienced changes in their artistic style as a result of brain damage. However, it should be underlined that the radical changes seen in the artists' styles are not only physiological, but may also be related to cultural and environmental factors.

essential to emphasize that the changes observed in artists' works following brain injuries may not solely stem from physiological alterations. Psychological and environmental factors post-brain injury can also influence artists' tendencies to develop different styles or approaches in their artwork.

One of the most intriguing effects of brain damage on artists is a class of phenomena in which the resulting art is surprisingly attractive. Damage to the right hemisphere can lead to left spatial neglect, where patients are not aware of the left side of space (Chatterjee and Neglect, 2003). Painters sometimes overlook the left side of the paintings they create or paint (Blanke, Ortigue and Landis, 2003). Two examples demonstrate how altering spatial perceptions can result in widely respected art.

Lovis Corinth, a well-known German impressionist, had right hemisphere paralysis in 1911. He maintained painting once he recovered. His self-portraits and portraits of his wife (Fig. 7) had distinct stylistic alterations, with features on the left occasionally removed and textures on the left mixing with the backgrounds. His later work, according to Alfred Kuhn, places him in the ranks of great painters (Gardner, 1975).

Figure 7: Lovis Corinth - Before and After Stroke Paintings

a)Die Nacktheit, 1909 (Before stroke)

b)Walchensee, Landhaus mit Wäscheplatz, 1920 (After stroke)

c) Study of the artist's wife (Charlotte Brerend), 1912 (After stroke)

d) Self-portrait, 1912 (After stroke)

Source: Blanke O, Pasqualini I., (2012). The riddle of style changes in the visual arts after interference with the right brain. Front Hum. Neuroscience, p.154.

Corinth created over 1200 paintings, several hundred watercolors, and hundreds of sketches and prints, according to Brugger (1992). He produced 67 paintings in 1911, the year before his stroke. This was reduced to 24 paintings in 1912. In 1913, his output increased to 53 works. Corinth created about 250 paintings between 1919 and 1925. With the large quantity of artwork produced by the artist's prodigious productivity over the years, research cannot cover all of Corinth's works, but Olaf Blanke's investigation has succeeded in offering an analysis of 54 of Corinth's self-portraits.

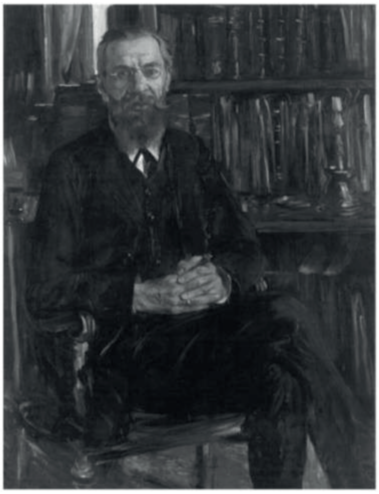

Figure 8: Paintings of Lovis Corinth

a) Portrait of Professor Eduard Meyer, oil on canvas, 140x180 cm, 1910-1911 (before stroke)

b) Woman in a Hat with Roses, oil on canvas, 60x50 cm, 1912 (after stroke)

Source: Chatterjee A., Bromberger B., Smith W.B., Sternschein R. and Widdick P. (2011). Artistic Production Following Brain Damage: A Study of Three Artists, Artists. Leonardo, p.407.

Loring Hughes' experience with pre-morbid accuracy of description after suffering from right hemisphere paralysis which was documented by Heller in 1994. Hughes set aside formal concerns following his paralysis in order to focus on his own imagination and feelings. His new works were warmly accepted by the art community at the time. His work has been defined as "a form of radical explosion of energy that had not previously existed" by critic Eileen Watkins.

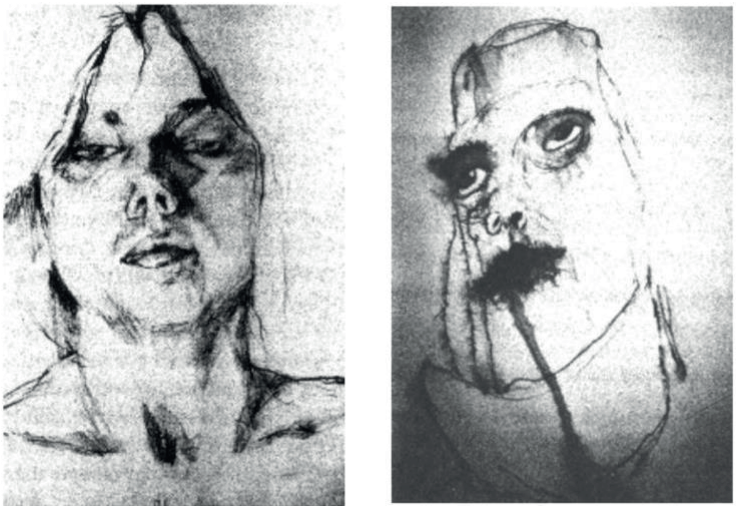

Figure 9: Portraits of Loring Hughes

a) Before brain injury

b) After brain injury

Source: Heller, W. (1994). Cognitive and emotional organization of the brain: Influences on the creation and perception of art. Neuropsychology, p.277.

The Bulgarian artist Zlatio Boyadzhiev and the American artist Katherine Sherwood both experienced the effects of left hemisphere injury. Boyadzhiev, who was born in the town of Brezovo, graduated from the Painting Department of the Academy of Fine Arts in Sofia in 1932. Before his illness (before 1951), Boyadzhiev's artistic style was known to be pastoral and pictorial. These works, considered to be his early works, were characterized by a neoclassical style with scenes from rural life. During these years, he frequently used neutral colors in his works.

Figure 10: Paintings of Zlatio Boyadzhiev

a) Landscape**,** Before Stroke

b)Montmartre, After Stroke

Source: Brown, J. (1977). Mind, brain, and consciousness. The neuropsychology of cognition. NewYork Academic Press.

Following his stroke, he started using his left hand in an entirely new manner. His formal style shifted dramatically toward grotesque imagery, hundreds of forms in compositions, and passionate colors. Boyadzhiev's paintings are now regarded as having more colorful, flowing, and dynamic lines (Brown, 1977). The artist's images got increasingly creative, even weird and surreal at times.

Katherine Sherwood had a left hemisphere hemorrhagic stroke. As a result, she suffered from aphasia and right-side weakness (Waldman, 2000). Sherwood, whose paintings were regarded as "very intellectual" until she suffered a stroke, thought she couldn't make such representations after the stroke, even though she wanted to. Her new painting style has been described as "raw" and "intuitive" with distinctive irregular circular movements.

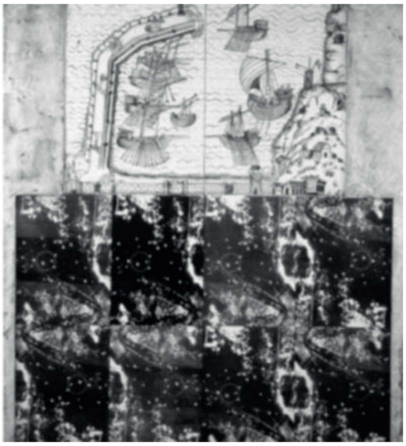

Figure 11: Paintings of Katherine Sherwood

a) Before Stroke Drawing

b) After Stroke Painting

Source: Chatterjee A., Bromberger B., Smith W.B., Sternschein R. and Widdick P. (2011). Artistic Production Following Brain Damage: A Study of Three Artists, Artists. Leonardo, p. 406.

5. CONCLUSION

The empirical aesthetic tradition that dates back to Fechner in the nineteenth century has only recently been embraced by neuroscience. Since the beginning of scientists' studies on aesthetics, similarities between the structure of the brain and works of art have been found. According to research, the nervous system guides a person to comprehend the fundamental aspects of the world, much like an artist. The nervous system divides visual information into separate components like color, brightness, and movement to process it. Similar to this, many artists have decided to isolate various visual aspects of their paintings, particularly in the previous century. For instance, Calder stresses movement whereas Matisse emphasizes color.

Cognitive neuroscience studies shed light on why art has been so widespread and valued throughout human history, while also showing that we perceive the art object by using our senses, perceiving external stimuli and assigning values to each input through a reward mechanism. It is worth underlining the role of the reward systems in our brains in our appreciation of art. Because research shows that when we look at a work of art that we find attractive, the reward centers of our brain are activated, releasing chemicals associated with pleasure and reward.

While it's clear that understanding the neurobiology of aesthetics increases our appreciation and creation of art, is there a point at which we ruin art by trying to quantify it? According to scientists, the answer is controversial; there doesn't always seem to be a common observation surrounding art because it is so personal and so tied to the reality of a particular individual. The findings suggest that there are some aesthetic "universals", recurring mechanisms that make different artistic expressions from distant cultural contexts beautiful, possibly due to the functioning of our brains, that appear in the formal characteristics of artistic works. But it is unlikely that the essence of art emerges from these mechanisms alone.

Although some art theorists may disagree with this result, these investigations show the new acceptance by scientists that visual aesthetics is a fundamental aspect of the human mind and must adhere to laws of neural structure. From the standpoint of neuroscience, the remarkable similarities between the goals and techniques of artists and the structure of the visual system give fresh ideas on aesthetic experience. On the other hand, scientific studies looking at how brain trauma affects artists make this new topic deserving of future clinical studies. The difficult part is developing experimental paradigms and testable hypotheses from these interpretations.

REFERENCES

Andersen, R. A., Snyder, L. H., Bradley, D. C. and Xing, J. (1997). Multimodal representation of space in the posterior parietal cortex and its use in planning movements. *Annual Review of Neuroscience,* Issues 20, p. 303-330.

Ishai, A., Fairhall, S. L. and Pepperell, R. (2007). Perception, memory and aesthetics of indeterminate art, *Brain Research Bulletin*, Vol.73, Issues 4–6, p. 319-324.

Barry, A. M. (2006). Perceptual aesthetics: transcendent emotion, neurological image. *Visual Communication Quarterly* 13.3, p. 134-151.

Blanke, O., Ortigue, S. and Landis, T. (2003). *Color neglect in an artist.* Lancet, 361.

Brown, J. (1977). *Mind, brain and consciousness. The neuropsychology of cognition.* New York: Academic Press.

Chatterjee, A. and Neglect, A., (2003). Disorder of spatial attention. D'Esposito M. Cambridge, MA: The MIT Press; *Neurological Foundations of Cognitive Neuroscience*. 2003a, p. 1–26.

Chatterjee, A. (2011). Neuroaesthetics: a coming of age story. *Journal of Cognitive*

Farah, M. J. and Malden, M. A. (2000). *The cognitive neuroscience of vision.* Oxford: Blackwell Publishers.

Gallese, V. (2013). *Mirror neurons and art.* Oxford University Press: Oxford, p. 441-449.

Gardner, H. (1975). *The shattered mind.* The person after brain damage. New York: Alfred A. Knopf.

Goodale, M. A., Jakobson L. S. and Servos, P. (2000). *The visual pathways mediating perception and prehension, cognitive neuroscience.* Oxford: Blackwell Publishers.

Heller, W. (1994). Cognitive and emotional organization of the brain: Influences on the creation and perception of art. N*europsychology,* New York: Academic Press, p. 271–292.

Karakaş, S. (Ed.) (2008). *Kognitif nörobilimler.* İstanbul: Nobel Tıp Kitapevleri.

Mishkin, M., Ungerleider, L.G., and Macko, K.A. (1983). Object vision and spatial vision: Two cortical pathways. Trends in Neuroscience, 6, p.414-417.

Mouncastle, V. B. (2000). *The parietal system and some higher brain functions, cognitive neuroscience.* Oxford: Blackwell Publishers.

Ramachandran, V.S . (2007). Three Clues Understanding Your Brain, TED Conference. https://www.ted.com/talks/vs_ramachandran_3_clues_to_understanding_your_brain

Ramachandran, V. S. (2011). *The tell-tale brain: A neuroscientist's quest for what makes us human.* WW, Norton Co.

Simon, H. A. (1962). The architecture of complexity. *Proceedings of the American Philosophical Society,* 106, p. 467–482.

Osaka, N. (2022). Emotional neuroaesthetics of color experience: Views from single, paired, and complex color combinations. Psych J. 2022 Oct;11(5):628-635.

Zeki, S. (1999). Inner Vision: An Exploration of Art and the Brain. Oxford and New York: Oxford University Press.

Zeki, S. and Moutoussi, K. (1997). Temporal hierarchy of the visual perceptive systems in the Mondrian world. Proceedings. *Biological Sciences/The Royal Society*. 264, p. 1415-19.

Zeki, S. and Marini, L. (1998). Three cortical stages of color processing in the human brain. *Brain* 121, p. 1669-1685.

Waldman, P. (2000). Master stroke: A tragedy transforms a right-handed artist into a lefty and a star. Wall Street Journal, May 12, Friday.