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Neuroscience in media arts: the connection between the human brain and the art experience

Neurociencia en artes mediales: la conexión entre el cerebro humano y la experiencia artística

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Abstract

This essay investigates in the interdisciplinary field that combines neurotechnology and artistic research to incorporate the current works of the latest generation. The overall goal is to investigate the connection between the brain and the human experience through a comparative analysis of contemporary works of art in various fields of neurotechnology, neuroart, and media arts. The methodology used in this study consists of both documentary and authorial review to generate a series of comparative analyses. The relationship between the artwork and the human brain was based on some results from the works of Dikker and Oostrik, and Lieberman. Neurotechnology, neuroart, and media arts are fields that have generated various discussions and debates in recent years. In conclusion, it is crucial to enhance interdisciplinary creation and collaboration through neuroscientific research.

Keywords: neuroscience, media arts, contemporary artist, technology, brain.

Resumen

El presente ensayo se indaga en el campo interdisciplinario que combina la neurotecnología y la investigación artística para incorporar las obras actuales de la última generación. El objetivo general es indagar la conexión entre el cerebro y la experiencia humana a través de un análisis comparativo de obras de arte contemporáneo en diverso ámbito de neurotecnología, neuroarte y artes mediales. La metodología utilizada en este estudio consiste, tanto en la revisión documental como en la revisión autoral para generar una serie de análisis comparativa. La relación entre la obra de arte y el cerebro humano se basó en algunos resultados de obras de arte de Dikker y Oostrik, y Lieberman. La neurotecnología, la neuroarte y las artes mediales son campos que han generado diversas discusiones y debates en los últimos años. En conclusión, es fundamental para mejorar la creación y la colaboración interdisciplinaria a través de la investigación de neurocientífica.

Palabras clave: neurociencia, artes mediales, artista contemporánea, tecnología, cerebro.

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Introduction

Many scientists and professionals have been widely studied, discussed, and disseminated through new interdisciplinary strategies through the machine (coding) in order to develop both brain activity and physical activity, thus establishing the best-known relationship with cognitive neuroscience (Alcívar-Alcívar & Moya-Martínez, 2020; Ebitz & Hayden, 2021; Lazar, 2018; Pinti et al., 2020). There is a connection between art and science to transform neurotechnology and neuroscience, as well as the complex relationship involving artist and scientist professionals who play different roles in creativity and sensory perception activity (Cinel et al., 2019; Cometa et al., 2022; Muntané & Moros, 2020; Vázquez-Guardado et al., 2020). Meanwhile, media arts are an interdisciplinary field that combines art, science, and technology to create artistic experiences involving the use of electronic, digital, and sound media (Bernaschina, 2021a; Botella, 2020; Cuesta et al., 2021; Li, 2022; Llamas, 2020; Marcos, 2007; Saquib & Habib, 2019; Singh, 2005; Trimarchi et al., 2019). Not all neuroscience has been used in the field of media arts; rather, the human brain responds to different artistic and technological stimuli. Thus, media arts use electronic media as an integral part of the creative process, including video art, interactive installations, digital performance, virtual reality, etc., and focus on exploring the relationship between technology and society.

It is possible to understand the connection between the human brain and artistic experience through neuroart works, deepening this understanding through authorial review in media arts; that is, each artist has their own brain-measurement technique and may create interactive works that respond to the brain activity of the viewer. Unlike neuroaesthetics, neuroculture deals with all forms of art (not only the visual arts) and does not seek to understand art in a neuroscientific way (Frazzetto & Anker, 2009, p. 815). Neuroaesthetics focuses specifically on the relationship between aesthetics and the brain, and seeks to understand how the brain processes and experiences the perception of beauty and art (Dietrich & Knieper, 2021; Iigaya et al., 2020; Jokeit & Blochwitz, 2020; Pepperell, 2018; Siler, 2015; Skov, 2019; Wolf, 2020; Zeki et al., 2020).

However, it is important to note that neurotechnology is an interdisciplinary field that combines neuroscience and technology to develop various tools and devices that allow the measurement, manipulation, and analysis of brain activity (Cinel et al., 2019; de León Barrios, 2022; Roberts, 2019; Vázquez-Guardado et al., 2020). Neurotechnology is also used in a variety of fields, including medicine, psychology, education, and the entertainment industry. For example, some applications of educational neurotechnology include the development of personalized teaching programs that adapt to the individual needs of students, the use of neuroimaging to study brain activity during the teaching-learning process, the implementation of neuroscience-based educational games to improve student motivation, and the application of virtual reality and augmented reality to create new school learning experiences (Casanova-Borjas, 2021, 2022; Meza & Moya, 2020). Educational neurotechnology can be a necessary tool for improving the quality and effectiveness of education in different contexts and educational levels.

Most artists work on a product of human creativity through study, practice, and observation in order to investigate the processes of artistic appreciation in a healthy brain by means of modern techniques such as neuroimaging and neuropsychology (Demarin et al., 2016; Frazzetto & Anker, 2009; Nadal, 2013). However, it is possible to understand the neurotechnology of digital media and media arts in order to provide new perspectives on human experience and interaction with multimedia art, such as the technological research instruments used in neuroscience. Some modern diagnostic techniques such as PET (positron emission tomography), MRI (magnetic resonance imaging), fTCD (functional transcranial Doppler ultrasound), and fMRI (functional magnetic resonance imaging) have made it possible to identify observation in different types of compositions and artistic forms, as well as the interaction of motor, sensory, cognitive, and emotional activity in the dominance of the cerebral hemisphere, which has led to possibilities for using music, painting, and dance as aids in the treatment of somatic, neurological, or psychiatric disorders (Bosnar-Puretić et al., 2009; Chatterjee, 2011; Dale et al., 2007; Horváth, 2018; Lundy et al., 2022; Saggar et al., 2021). This becomes transformed into neuroart.

Neuroart is an interdisciplinary field of research that combines neuroscience, technology, and the visual arts to explore the relationship between the human brain and artistic experience (Gingrich & Rahman, 2022; Karpov & Syrotynska, 2018; Ursu et al., 2022). Neuroartists employ brain measurement and stimulation technologies to investigate the relationship between neural processes, aesthetic perception, creativity, and emotion in response to the work of art.

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Not all neuroart works produce artistic pieces from data obtained through brain activity; rather, there is a deep understanding of the reaction of the human brain when perceiving visual and auditory stimuli that contribute to artistic understanding and to the improvement of mental health, learning, and creativity.

The general objective is to investigate the connection between the brain and human experience through a comparative analysis of contemporary artworks in the diverse fields of neurotechnology, neuroart, and media arts. The specific objectives are: (i) to identify the main theories and concepts related to neuroart and media arts, as well as their relationship with neuroscience and artistic experience; (ii) to compare neuroart tools in order to deepen the observation of contemporary artworks, with the aim of identifying patterns of brain activation associated with innovative experience and with the understanding of new media artworks; and (iii) to involve both interactivity and technology in creating new forms of art that directly engage the viewer in the neuroart experience. To this end, it is important to deepen knowledge of the sensory and neural processes associated with artistic experience in contemporary artworks, especially in the context of new digital and multimedia technologies; likewise, the aim is to explore the application of neuroscience in order to understand its impact on human perception.

Methodology

The methodology used in this study consists of both a documentary review and an authorial review of works in media arts, neurotechnology, and neuroart in order to analyze and compare the characteristics of these works in relation to the brain and technology in artistic experience. A broader search was carried out in sources such as scientific and contemporary art databases, specialized publications, and relevant articles. Likewise, a rigorous and systematic approach was applied to select the documents, ensuring their quality and relevance. Once these relevant documents were selected, a critical and detailed analysis of each work of art was conducted, paying attention to aspects such as form, content, context, and the response within neuroart research. Special consideration is given to the relationship between the work of art and the brain, as well as to how neurotechnology in media arts influences the artistic experience through new technologies..

This key characteristic of neurotechnology in media arts explores the potential of neural decoding and brain-computer interfaces in the domain of art (Bernaschina, 2019; Bojić, 2022; Rowland, 2021). This combination of technology and neuroscience allows artists to explore new forms of expression and create media art experiences for viewers that involve brain activity in real time. Neurotechnology can also help artists better understand how the human brain processes information and responds to visual, auditory, and sensory stimuli, which may inform their work and provide new perspectives on human experience. In addition, neurotechnology and media arts often focus on interactivity and viewer participation. Likewise, the devices and sensors used in these works of art often respond to the viewer's brain activity and other physiological data, allowing for a more personalized and participatory experience. In this sense, neurotechnology seeks to obtain valuable information from both the brain and the human mind in order to produce works of art, with applications in medical research and the treatment of mental disorders, whereas media arts seek to create innovative works of art and experiences for the general public. For example, the comparative table between (artistic) neurotechnology, neuroart, and media arts (Table 1).

Table 1

Comparison of Neurotechnology, Neuroart, and Media Arts

Characteristics	Artistic Neurotechnology	Neuroart	Media arts
Objective	To integrate technology and neuroscience into artistic creation in order to improve the understanding and experience of art.	To understand perception and artistic creation, as well as to improve the therapy of various medical conditions through the application of neuroscientific findings.	To explore the relationships between art, technology, and society, and to experiment with electronic and digital media in order to produce interactive and multisensory works of art.
Main techniques	EEG, MRI, tDCS, BCI, etc.	EEG, MRI, MEG, fMRI, psychophysics, statistical and computational analyses, etc.	VR, AR, AI, sensor technology, 2D/3D printing, robotics, programming, multimedia, interconnection technologies, etc.

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Table 1. Continued on the next page

Comparison of Neurotechnology, Neuroart, and Media Arts

Main applications	Treatment of neurological diseases, rehabilitation, improvement of cognitive performance, diagnosis of neurological diseases, brain-computer interfaces for persons with disabilities.	Understanding perception and artistic creation, therapy for various medical conditions, design of interactive experiences, research in neuroscience, exploration of the relationship between art and science.	Production of interactive and multisensory works of art, development of new forms of artistic expression, experimentation with emerging technologies, exploration of the intersections between art and technology.
Target audience	Patients, researchers, health and arts professionals.	Artists, educators, therapists, researchers, and the general public..	Artists, designers, researchers, professionals, and the general public.
Main results	Improvement in patients' quality of life, rehabilitation and recovery of cognitive and motor functions, diagnosis and treatment of neurological and psychiatric disorders, advances in research and understanding of neuroscience, development of new technologies.	Improvement of creativity and artistic perception, exploration of the relationship between the brain and art, therapeutic use in the treatment of neurological and psychiatric disorders, development of new teaching and learning methods.	Exploration of the relationship between technology and creativity, innovation and experimentation in the field of art and design, development of new forms of communication and artistic expression, advances in research and understanding of the relationship between technology and culture.
Sources recommended by PubMed (English-only)	Cinel, Valeriani & Poli (2019); Vázquez-Guardado *et al*. (2020).	Bosnar-Puretić, Roje-Bedeković & Demarin (2009); Demarin *et al*. (2016); Lundy, James & Reybrouck (2022); Nadal (2013); Pepperell (2018); Siler (2015); Zeki, Bao & Pöppel (2020).	Li (2022); Marcos (2007); Singh (2005); Trimarchi, Martino & Bartalena (2019).

Note: EEG = electroencephalography; MRI = magnetic resonance imaging; TMS = transcranial magnetic stimulation; tDCS = transcranial direct current stimulation; BCI = brain-computer interfaces; MEG = magnetoencephalography; fMRI = functional magnetic resonance imaging; VR = virtual reality; AR = augmented reality; AI = artificial intelligence.

Results

Neurotechnology is used in media arts to study and modify brain activity in response to works of art that involve technological media such as virtual reality, augmented reality, video art, and interactive installation. In media arts, neurotechnology is used to understand the viewer's aesthetic experience and to measure people's brain activity while they experience a work of art. This provides information on how the brain processes and responds to visual and auditory stimuli. In addition, neurotechnology has also been used to create interactive works of art that respond to the viewer's brain activity in real time. Installations have been developed that vary according to the viewer's degree of attention or relaxation, or that react to people's brain wave patterns. This approach enables neuroartists to design works of art that adjust to individuals' experiences and can be used to develop new forms of interactive and personalized art.

Neurotechnology in media arts is an innovative field that explores the connection between the human brain and artistic experience. By using neuroscience techniques, it is possible to understand how the brain responds to art, which allows artists to create works that are especially meaningful and moving. Some of the most interesting results in media arts, neurotechnology, and neuroart include:

1. Creation of works of art that stimulate brain activity: by understanding how the brain responds to color, form, and other artistic elements, artists can produce works of art that activate specific areas of the brain. Such works can generate a significant impact on people, stimulating emotion, creativity, and reflection.

2. Development of neurofeedback techniques to enhance the artistic experience: neurofeedback (Hampson et al., 2020; Kovacevic et al., 2015) is a technique that allows individuals to see in real time how their brain responds to different stimuli. Artists can use this technique to help people understand how their work of art activates the brain, which can enhance the artistic experience and understanding itself.

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3. Research on the impact of art on the human brain: neuroart can help those engaged in science better understand how art affects the human brain. This can have important implications for mental and emotional health, since exposure to art has been shown to reduce stress and improve well-being.

4. Interdisciplinary collaboration: neuroart is a field that fosters collaboration among artists, scientists, therapists, and other professionals. By working together, these professionals can create works of art that are more effective for therapy, education, and research.

This connection between the human brain and artistic experience is a complex topic that has been investigated in neuroscience and neurotechnology in recent years. Neurofeedback measures brain activity in real time and provides visual or auditory feedback to help people regulate their brain activity. In the context of art, neurofeedback can be used to examine how the artistic experience affects brain activity. This may have implications in various fields of media arts, cognitive neuroscience, and technology (Table 2).

Table 2

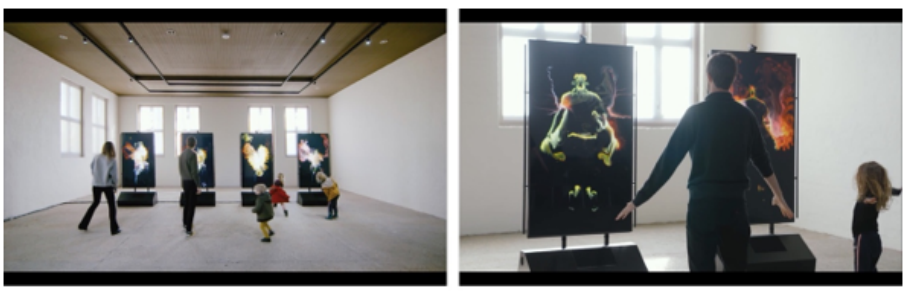
Comparison of Media Arts, Neurotechnology, and Neuroart

Links Between the Human Brain and Artistic Experience.	Art and Neurofeedback
- Research in neuroscience and neurotechnology - Technique for measuring brain activity in real time (neurofeedback) - Provides visual or auditory feedback - Helps regulate brain activity	- Exploration of how artistic experience affects brain activity - Regulation of brain activity may affect artistic experience - Implications for the field of neuroart and neurotechnology (intersection between media arts, cognitive neuroscience, and technology)

In order to foster new forms of media arts, neurotechnology, and neuroart through sensory perception, depending on the examination of the relationship between the human brain and artistic experience—part of the individual experience undergone when interacting with a work of art, which may include emotions, reflections or thoughts, and physical sensations through the work produced in the observer—through neuroscience techniques that transform the understanding and experience of new media art. However, there is the contemporary neuroart work Harmonic Dissonance Quartet [Cuarteto de Disonancia Armónica], created by the Dutch artist and cognitive neuroscientist Suzanne Dikker together with the Dutch interactive artist and designer Matthias Oostrik, the Dutch composer Than van Nispen, and the Dutch musician Ivo van Dijk, in order to explore the interaction between the brain and music, using neuroscience techniques to investigate communication among musicians during a live performance (Figure 1).

Figure 1

Screenshots of Harmonic Dissonance Quartet (2022) by Suzanne Dikker and Matthias Oostrik. Audiovisual installation (4 video channels, 4 audio channels, 4 infrared camera channels, steel and wood materials, footprint WDH 12x7x3 meters, C++ software, OpenPose, openFrameworks, FMOD). Infinite duration.



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Note. Oostrik (n.d., 2022).

This neuroart work by Dikker and Oostrik is a playful installation that merges art and science, in which the audience dances and moves in front of large audiovisual instruments that, when played collectively, unlock new levels of play and evolve the installation, creating constantly changing compositions that oscillate between harmony and dissonance, while objective data are translated into intuitive narratives for participants and spectators thanks to the collaboration between scientists and artists.

Another project by Dikker and Oostrik, NeuroTango, is a live experiment that uses wireless headsets to detect the brain waves of tango dancers in synchrony; the work has shown that dancers experience high brain synchronization during dance and that this can be reinforced through tango training, and the results are visualized in real time through dynamic projections on the walls (Dikker, n.d.). A live experiment was conducted at Cantina Royal, a venue located in the Williamsburg neighborhood of Brooklyn, New York, in 2014 (Figure 2).

Figura 2

Screenshots of "NeuroTango" (2014) by Suzanne Dikker and Matthias Oostrik.

Note. The Daily Dot. (2014a, 2014b).

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These are not only unique projects by Dikker and Oostrik; rather, there are many neuroart works that have emerged from the neuroscience experiments of the Mutual Brainwaves Lab, using interactive neurofeedback to track and visualize brainwave synchronization in real time, as if two heads were merging into and out of one another (Dikker, n.d.).

Ha creado obras de arte interactivas que utilizan tecnologías de detección y visualización, incluyendo la neurotecnología, para explorar temas relacionados con la percepción y la cognición. Por ejemplo, un proyecto "EyeWriter" fue iniciado en 2009 por un grupo de artistas y diseñadores, incluyendo a Zachary Lieberman, como una respuesta a la esclerosis lateral amiotrófica (ELA) que sufría el artista callejero neoyorquino Tempt One (EyeWriter, n.d.). La enfermedad lo dejó paralizado, incapaz de mover su cuerpo, con excepción de sus ojos. Lieberman y su equipo diseñaron un sistema que utiliza una cámara infrarroja y un software de seguimiento de ojos para capturar el movimiento ocular y traducirlo en líneas y formas en una pantalla o superficie (Figura 3). La tecnología se ha utilizado para crear obras de arte expresivas y para ayudar a las personas con discapacidad física a comunicarse y expresarse creativamente, permitiéndoles dibujar en tiempo real usando sus ojos en una pantalla o superficie.

Figura 3

Screenshots of test project

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Discussion

Neurotechnology, neuroart, and media arts are fields that have generated various discussions and debates in recent years. Nevertheless, some critics have questioned the ethics of neurotechnology in art, arguing that the measurement and manipulation of brain activity can be invasive, and may even violate the privacy and consent of viewers. They have also expressed concern about the potentially manipulative use of neurotechnology in advertising, politics, and other areas. On the other hand, defenders of neurotechnology and media arts have argued that these fields enable the use of new forms of creative expression and, of course, provide a better understanding of human experience and interaction with art. They have also highlighted the potential of neurotechnology to improve education, the treatment of mental illness, and other fields related to medicine and therapy.

However, this integration of media arts into the diverse field of neuroart and neurotechnology can have a significant impact on sensory perception, both for the human brain and for the body. By incorporating media arts through the range of tools and techniques available for the study of these technological-artistic instruments, it could result in new experiments and creative advances (Bernaschina, 2019, 2021b, 2022; Graham, 2016; Jones & Muller, 2008; McCarthy & Ondaatje, 2002; Pérez, 2012). In addition, media arts offer new ways of communicating complex information about the brain and the mind to the general public, for example, through the use of virtual reality, augmented reality, or video games. It is important to foster interdisciplinary collaboration among artists, scientists, and mental health or education professionals, which may lead to a more complete and holistic understanding of the human brain and mind. This, in turn, could improve medical care and mental well-being, and of course, people's school learning.

Conclusions

In conclusion, artistic neurotechnology, neuroart, and media arts are interdisciplinary fields that combine technology and cognitive neuroscience with the creation of works of art by Dikker and Oostrik, and Lieberman, offering new creative and exploratory possibilities for all artists and greater interactivity, and of course with the participation of the person who experiences the work of art. While these fields have generated various discussions and debates about ethics, their potential, and their limitations, it is important to explore their use and application in art and other areas. Neurotechnology in media arts also has the potential to improve education, medicine, and other disciplines, and it is expected to continue to be an area of research and development in the artistic-technological future.

The inclusion of media arts in the field of neuroart and neurotechnology is essential for advancing the understanding of complex issues related to the brain and the mind, and of course the body, in order to improve creativity and interdisciplinary collaboration through neuroscientific research. In addition, interactivity and viewer participation in art can be considered an opportunity to democratize the artistic and technological experience, while fostering a deeper emotional and cognitive connection with the neuroart work.

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Authors' Contributions

Author	Contribution
Diego Bernaschina	All the authors jointly and equally contributed to the conception, drafting of the article, data acquisition, analysis and interpretation, and revision of the article.

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