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A Combination of Art, Creativity and Neuroscience

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ABSTRACT

The concept of creativity has many aspect. Whether it is a simple act of innovation or a grand work of genius, creativity and innovation shape the way we live, think, and believe. With case studies of artists with neurological diseases and their experiences with their disease, we review the construct of creativity, describe the neural mechanisms underlying these effects, and explain the influences of art on creativity. In psychology and neuroscience, creativity is a topic of great interest, but the findings of studies are not always consistent. A difficult domain to study may partly explain inconsistent findings when it comes to creativity. Nevertheless, creativity is a vital element of human culture, hard to define and even harder to capture. Creative thinking is delineated in different ways by different researchers, as well as different paradigms and explanations for how it works.

Keywords: Creativity, Art, Neuroscience

Introduction

Philosophers, historians, anthropologists, artists, and, more recently, neuroscientists have discussed the nature of the human creative process, both in the creation and study of art. The latter's inclusion has sparked debate and suspicion among established schools of thinking, although neuroscience researches have supplied an alternate perspective, however, using real neuroscience data, neuroscience research have given various and frequently conflicting perspectives and techniques for understanding the brain basis of the human creative process.

Common definition

How can creativity be defined? A common definition of creativity is provided by Webster's II University Dictionary (1988), "having the power or ability to create," "productive," "marked by originality," and "new." In this definition of creativity, production and novelness are both emphasized [1].

Production

It makes sense that production is essential to creativity since an abstract concept can fail when put into practice. A creative concept must move beyond imagination to become a tangible product [1].

Novelty

Creative thinking, or the creative process, enables individuals to create novel products, provided they were unaware of the concept before engaging in the process [1].

Value

To be considered creative, work must also have value as well as be novel [2, 3]. A detailed analysis of the relationship between novelty and value in the creative process was provided by Csikszentmihalyi (1988, 1996, 1999). Novel products can become creative once they are accepted as "part of the domain" or valued by the "field". If "the field" rejects a product or idea, it is not creative, according to this viewpoint [4].

Unity in diversity

The definition of creativity that Bronowski (1972) uses differs somewhat from that used in some research.: "Creativity is finding unity in what appears to be diversity" [5]. St. Augustine, who lived in the 5th century, was the first to express unity in diversity.

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Frances Hutcheson wrote on unity in diversity in relation to creative undertakings like music as early as 1725. A wide range of colors and shapes can be found in many great visual works, just as many great musical pieces display an array of melodies and rhythms. In painting as well as in a symphony, the creator develops a thread that binds together seemingly disparate elements, bringing order to what might otherwise seem chaotic. As a characteristic of creativity, this definition emphasizes the notion of a "global approach. "Unfortunately, these two previously mentioned features are absent from this definition. In addition, the related definition offered by Heilman and colleagues describes creativity as a process of understanding, developing, and expressing orderly novel relationships in a systematic manner [6].

The Neurobiology of Creativity

Several reports showed that some areas act in the brain such as a neuronal network are active in the creative process. The following section provides examples of how neurological diseases may affect various cognitive mechanisms that might serve as a foundation for creative thinking. Moreover, certain parts of the brain are linked to creativity, as well as their involvement in neurological diseases will be discussed.

The involvement of the nondominant (right) hemisphere in creativity

According to Bruce Miller and colleagues, patients with frontotemporal lobar degeneration may develop artistic abilities [7]. As the name implies, during frontotemporal lobar degeneration, the frontal and temporal lobes are the most affected parts of the brain. The degenerative frontotemporal lobar disease has three main types: behavioral variant frontotemporal dementia (affecting nondominant hemisphere frontotemporal areas), progressive nonfluent aphasia (affecting dominant hemisphere frontotemporal areas), and semantic dementia (affecting bilateral anterior temporal lobes predominantly). Furthermore, logopenic progressive aphasia [also known as logopenic progressive aphasia, is the most recently recognized variation of a primary progressive aphasia (LPA). A unique speech and language pattern results from damage to the left temporoparietal junction [8].
Miller mentioned that some of the patient began drawing or painting as soon as they began to show indications and symptoms of dementia. Although these patients had progressive dementia, some of them painted and some of them even improved their artistic skills. Although people with these types of dementia can debate whether they promote creativity and abstraction rather than reducing productivity and increasing work distortions as dementia develops; the fact that they can make art at all is impressive [9, 7].

What impact does frontotemporal lobar degeneration have on those who are already accomplished artists? Mell was the first case report to address this question [10]. The report mentioned a woman who was an artist before being diagnosed with the condition. Throughout her disease, she continued to produce art, though her artwork began to exhibit evidence of hemispatial neglect and serious deterioration in the later stages of her illness. Finney and Heilman employed an artistic quality evaluation instrument and had impartial assessors analyze the artwork to quantify variations in the patient's artwork before and after the onset of dementia [11]. A number of qualities were assessed, such as novelty, aesthetics, representation, technique, and closure. It is interesting to note that, during the period that art was available, there were no noticeable changes in ability. And despite the fact that the raters were unaware of the sequence in which the paintings were completed, they determined that the ones completed most recently were the least unique. It should be emphasized that the patient's artwork displayed lightened color palettes, simplified details, and distorted angles.
In a similar study, Drago et al. examined 40 artworks created by someone suffering from semantic dementia [12]. As with previous studies, study results showed an improvement in certain visual artistic skills over time. Kapur explains that a brain dysfunction may trigger the facilitation of a function by destroying an inhibitory circuit (i.e., "paradoxical functional facilitation [13]. Miller and his colleagues' results suggest that a similar phenomenon may be playing a role in the discovery of talent in patients with left anterior temporal lobe degeneration [9, 7]. There is no doubt that the aforementioned studies provide valuable insights into individuals with FTD's visuospatial abilities and visual creativity, and some would suggest that they also illuminate creative systems in patients. All the research that illustrates how brain injury affects one's capacity to produce visual art should be included. The consequences of brain injury on the ability to generate visual art are strikingly different from the effects of brain damage on many other human capacities. When we have a brain disease, we often have difficulty comprehending or speaking languages, coordinating movements, or recognizing objects. While brain illnesses can affect one's ability to create art, it's not always clear that the outputs are "impaired." It has been reported that, paradoxically, in some cases, patients are more creative and their art is better [14].

The involvement of the frontotemporal lobes in the hemisphere of the brain

In Edison's words, "ninety-nine percent sweat, one percent inspiration" is what it takes for a creative genius to succeed [18]. People who are creative need persistence and perseverance to be successful. Volition and goal-oriented behaviors are primarily controlled by the frontal lobes. Degenerative frontal lobe disease often results in a decline in motivation and initiative (abulia). Frontal intelligence, according to Heilman, is described as the capacity to set and sustain long-term objectives, as well as the ability to suppress biological urges that interfere with these goals and the ability to persevere without distraction [6]. In all professions, including those that require creativity, As Heilman said, "frontal intelligence" is probably the most important component.

There seems to be another function served by frontal lobe networks as well is associated with creativity: divergent thinking. Divergent thinking involves taking a different approach to preexisting modes of thinking and expression [14]. It has been suggested that frontal lobe dysfunction may interfere with divergent thinking. When performing creative tasks, by measuring regional cerebral blood flow, creative people have more baseline frontal lobe activity, and higher frontal lobe activity increases [5]. The effects of applying transcranial magnetic stimulation to the frontal lobes on creativity have also been demonstrated in healthy participants while they are drawing or writing [19]. A few reports have described patients who experienced improved creativity after electrodes were placed above and near the nucleus accumbens, which were tightly affiliated with the frontal and temporal lobes, to provide deep brain stimulation [20, 21]. Planning and organization are handled by dorsolateral prefrontal cortex, while emotion and drive are handled by the cingulate cortex. Also, the limbic system may affect creative drive through its interaction with the frontal lobes and temporal lobes [20]. A dysfunctional temporal lobe and increased dopaminergic activity increase creative drive. The creative blockage is caused by inactivity in the frontal lobes or reduced dopaminergic activity.

The involvement of *other gray matter systems' involvement in creativity*

SPECT, PET, and FMRI stand for single-photon emission computerized tomography, positron emission tomography, and functional magnetic resonance imaging have all been used to study the neurobiology of creativity (fMRI). SPECT was used by Chavez et al. (2004) to investigate the creative activity of 12 highly creative participants while doing figurative and verbal tasks. Right parahippocampal gyrus, bilateral rectus gyrus, right inferior parietal lobule, and right postcentral gyrus researchers discovered that cerebral blood flow is positively connected with the creativity index. These findings corroborate the idea of a "highly dispersed brain system" that fosters creativity, according to the researchers [22]. Normal participants were analyzed using PET while undertaking verbal creativity tasks, and the left parieto-temporal brain regions (Brodmann's areas 39 and 40), which are considered "crucial" to the creative process, were extremely active [23]. When creative and non-creative story generation were contrasted with the creative narrative generation, an fMRI study identified significant activations in the left anterior cingulate gyrus (BA 32) and the bilateral medial frontal gyri (Brodmann's regions 9 and 10). There isn't a lot of agreement across studies about if a creative activity is more important in the frontal or posterior brain areas.

The involvement of white matter in creative thinking

Because new connections are leading to creativity, intra- and interhemispheric communication between multiple brain systems may be required. As an example, the sculptor must use the non-dominant right hemisphere to evoke rotations of spatial images while using the dominant left hemisphere for motor skill control. Therefore, intra-and inter-hemispheric communication could be crucial for bringing together knowledge and abilities from both hemispheres, especially in novel ways. The corpus callosum is the most massive white matter structure in the brain, connecting the two hemispheres, which represent "independent" modular systems. Before and after cerebral commissurotomy, Lewis (1979) administered a Rorschach exam to eight patients with drug-resistant epilepsy. As measured by this test, the disconnection of the two hemispheres of the brain diminished "creativity" [24]. The corpus callosum was suggested by Frederick Bremer to be in charge of the brain's most complex and greatest processes, including, perhaps, creativity. The corpus callosum is mostly made up of myelinated axons with cell bodies in the cerebral cortex's pyramidal layers.

Important connections in the brain for creativity may also require intra-hemispheric connections as well as those interhemispheric. In addition to transmitting information between hemispheres, the thalamus and basal ganglia, and the cortex, myelinated axons also transfer information between regions within the same hemisphere.

Intra-hemispheric connections enhance intra-hemispheric communication, which could have a big impact on creative creativity since widespread connectivity allows people to mix previously isolated ideas.

Mednick (1962) claimed that creative persons have a larger associative network or hierarchy than less creative people, allowing them to activate larger, more widely distributed networks in response to stimuli [27].

Illness and Creative Drive

The effect of bodily illness

It has been argued that any illness can stimulate creativity [14]. Tubercular fevers, for instance, were thought to produce a hectic creative state in the nineteenth century. Hospitals would be much more stimulating institutions if illness typically encouraged creativity. In some cases, illnesses can arouse arousal and inspire a search for innovative solutions, or at the bare minimum, distractions. When a patient is very ill, they create less, indicating that necessity inhibits invention [28]. As the poet, "When you are insane, you are busy being insane all the time… When I was crazy, that's all I was" Sylvia Plath once stated [29].

The effect of brain illnesses

An aspect of the neuropsychology of art is presented in this section. I will look at cases when brain injury leads to a paradoxical increase in artistic output [13]. The effects of brain injury on visual art stand out sharply among practically all other complicated human abilities. Brain illnesses can limit our capacity to communicate, coordinate actions, recognize objects, interpret emotions, and make rational decisions. Despite the fact that brain disorders might impair one's ability to create art, these changes can be fascinating and even regarded as improvements in some cases [30].

The paradoxical facilitation of visual art

In a debate about the paradoxical facilitation of art, the idea that there is no single art center in the brain is implicit. One hemisphere does not dominate art production. In actuality, creating art is a highly complex process involving several components mediated by multiple areas of the brain. Coordination of these components leads to the final artistic outcome. A brain injury alters the parts of the brain responsible for overall creative production, which becomes the result of various component coordination. The weights of these brain systems are in a condition of equilibrium. The entire structure may collapse if a certain weight is removed. The configuration, on the other hand, can discover a new state of rest that is distinct from the original but equally appealing. An artist's ability to work may be harmed by brain injury. In either case, the art can obtain new and interesting configurations as a result of the new equilibrium. Neurological disorders can improve art production in four ways [30]. These are 1) a desire to create visual art; 2) the provision of a distinct visual vocabulary; 3) descriptive accuracy aids, and 4) modifications in expressive abilities.

Desire to create visual art

People with frontotemporal dementia (FTD) experience significant alterations in their social interactions. They tend to be disorganized and uninhibited. Language, attention, and decision-making skills may be impaired. Along with these changes in personality and cognition, some individuals with FTD produce art for the first time. There is an obsessive quality to it and it is highly detailed. It looks that the patients are completely absorbed in their work. People with FTD appear to have a relationship between their artistic production and personality alterations. As part of their repetition and preoccupation, those with obsessive-compulsive characteristics frequently exhibit stunning visual visions. Other examples demonstrate how neurological diseases can render obsessive-compulsive traits which can lead to artistic expression. Franco Magnani is a San Francisco-based Italian painter who was described by Sacks. During his career, Magnani created hundreds of realistic pictures of Pontito, his hometown in Italy, where he grew up. Magnani probably had an encephalitic illness at 31. After his illness, he painted compulsively. His conversations and thoughts were occupied by Pontito. Sacks hypothesized that he was suffering from partial complex seizures and had a "sticky" disposition, which is commonly associated with temporal lobe epilepsy. Some of these patients are hyper-graphic, which means they write all the time. Magnani's hypergraphia had a visual rather than a verbal manifestation.

A builder who experienced a subarachnoid hemorrhage was the subject of Lythgoe and colleagues' study. (Lythgoe, Polak, Kalmus, de Haan, & Khean Chong, 2005). Additionally, he was not interested in art premorbid, but after recovering from the initial injury, he became an obsessive artist. His verbal and performance IQs were normal after the hemorrhage, as well as his behavior, except for a certain degree of disinhibition. Except for those tasks requiring mental flexibility, he did well on most neuropsychological tests. He also started drawing hundreds of sketches, particularly of people's faces. Then he progressed to large-scale drawings, which often took up entire rooms and focused on a few topics. Savant-like talents are demonstrated in about 10% of youngsters with autism. Many of these children create striking visual images. A case of this sort was described by Selfe in Nadia. When Nadia was a newborn, she didn't respond to her mother. As a kid, she was preoccupied with other kids, but she did not build deep ties with them. Language acquisition was delayed for her. She was remarkably skilled at drawing despite these developmental abnormalities. As early as age three, she was drawing lifelike horses. She concentrated on drawing for a short period of time, constantly imitating pictures. She also drew hundreds of instances of specialized image categories, such as horses. Nadia's powers were impressive, but not unusual. It appears that autistic youngsters with exceptional drawing talents concentrate on one or more subjects and sketch them frequently. Neurological illnesses that induce obsessive-compulsive behaviors may also lead to a desire to create art. Artists who produce realistic images tend to concentrate on a small number of themes [14].

The provision of a distinct visual vocabulary

Neurological illnesses like as migraine and epilepsy have been linked to creative visual abnormalities. The British Migraine Association and WB Pharmaceuticals sponsored the first National Art Competition, which received almost 200 entries. 70 percent displayed spectral appearances, 48 percent fortresses, 16 percent vision loss, and 2.5 percent mosaics describing how migrainous auras influenced his work. Migraines, which he first experienced at the age of 11, were followed by terrifying periods of vision loss, with zigzag clouds covering much of his vision. He observed triangles, rounded shapes, and mosaics as he grew up. In addition, he saw that items were distorted and becoming larger or smaller. The following is how he describes the impact of migraines on his painting: "When I was in art school, I started with photos of my migraine experiences unconsciously rather than deliberately." At the time, I was doing a lot of landscape drawings and noticed that I was sketching clouds everywhere, not just in the sky, which I believe was a metaphor for the visual voids experienced during sight loss. In my works, I also used serrated zigzag forms to represent the sense of a whole being broken up... Clouds, zigzags, and other visuals are all part of my particular visual vocabulary, but they all have their origins in migraines. I am completely certain. That isn't something I do on purpose. In my works, I also used serrated zigzag forms to represent the sense of a whole being broken up... Clouds, zigzags, and other visuals are all part of my particular visual vocabulary, but they all have their origins in migraines. I am completely certain. I don't do it on purpose, but when the subject calls for it, such as to convey a mood or emotion, I employ these photos in a variety of ways. Patients like these provide insight into how artists frequently employ the visual lexicon. Further examination of these situations may shed light on how artists create visual vocabularies and visual grammar for concatenating these vocabularies [14].

Descriptive accuracy aids

For a long time, visual artists have been obsessed with conveying accurate representations of objects and their surroundings. Visual agnosias are a set of diseases that affect people's ability to recognize objects. Object recognition problems are thought to sit between perceptual and conceptual problems, as described by Lissauer in his classic descriptions of visual agnosias. Apperceptive agnosias, also called perceptual agnosias, are disorders that affect the capacity to interpret visual input into coherent objects. Associative agnosias, also known as conceptual agnosias, are characterized by a lack of semantic awareness about the item. Wapner, Judd, and Gardner (Wapner et al., 1978) reported an artist who had trouble duplicating images while being able to convey depth and shade in otherwise fragmentary works. His semantic system, which he had kept, was ineffective in directing his artistic output. As a result, he rationally constructed images in order to draw a phone, for example: “It needs a base for it to stand on, a place to speak into, something to hear with a wire to plugin for communication and a place to dial.” This verbal method proved ineffective in generating correct images. Rendering objects accurately does not rely on semantic knowledge alone. This patient was compared with two individuals with associative agnosias. Both groups created rudimentary, simple pictures, comparable to what a child would draw when instructed to draw objects from verbal labels. When drawing from complicated visual pictures, however, the outcomes were quite different. One of these professionals may, for example, create a magnificent copy of Botticelli's original portrait or a portrait of a staff member. Without semantic knowledge, people can render objects accurately and beautifully [14].

Modifications in expressive abilities

Of all, visual art is about more than just precisely depicting objects and scenes. With the invention of photography, visual art took on a variety of new forms. One of the most intriguing impacts of brain damage on artists is the inability to generate precise portrayals, which leads to unexpected aesthetic shifts. Changes in the usage of color, form, and content of images can all be seen. Sacks described an artist with acquired achromatopsia after a catastrophic brain injury. He painted colorful abstract paintings in the past. After the accident, everything seemed "filthy gray" to him. After his early attempts at using color failed, he resigned himself to painting in black and white. Later on, he began to use only a few colors in his paintings. Despite feeling helpless at first, he recognized his new viewpoint as a gift. In what he thought was a world of pure form bereft of color, he discovered a new variety of expressions. I highlighted the prospect of brain injury increasing artistic performance as I evaluated the research on the neuropsychology of artistic creativity. Of course, this is based on the observations of a few artists. Several different artists may be affected by undisclosed brain injuries. It is simply unknown what the basic rate of facilitation effects is. Yet, we can see that the nature of art is multidimensional. As proven by examples of work that has changed and possibly improved as a result of brain trauma [14].

Medical Treatments and Creative Drive

Any treatment that affects creativity affects the brain. Some of these treatments are not marketed as psychoactive. Patients who take hypertension or nausea medications may not be aware of the creative effects they may be experiencing. It is rare for drugs to increase creative ability, except indirectly by enhancing motivation for constant practice. Several drugs have been found to influence creativity by affecting motivation and arousal. Normal subjects, on the other hand, have a well-developed homeostatic system for the regulation of motivation and arousal. Once a drug is stopped, the homeostatic mechanisms begin to respond to the drug effects, leading to drug tolerance and rebound symptoms.

There are ethical and practical issues associated with the use of medications that affect creative motivation. It is important for patients and doctors to weigh the benefits of any treatment against the risks it poses to their health and social connections. For those who are very ill, as well as those who work in dangerous environments, creative pursuits may have to be temporarily abandoned. In light of both current studies and the practice patterns of experts in the field, therapeutic approaches can be suggested, although definitive solutions are not yet clear [29].

Nondrug Interventions

Many creative people believe that even small changes in their environment can stimulate or inhibit their creativity, such as leaving the office to work in a café or being praised by a mentor. The effects of such environmental factors have, however, been studied little [29].

Sleep and exercise

The alternation of these two activities benefits creative work, despite them in some way diametrical opposition. In particular, REM sleep stimulates associative networks and enhances creativity [31]. During sleep, sleep-related activities are performed that are traditionally associated with early incubation. Sleep disruption itself may not have as many negative consequences as daytime sleepiness. The only time that is available for creative work may be reduced if one sleeps too much. Some creative subjects can suffer from hypomania or manic episodes when they sleep too little. The benefits of regular physical activity are stronger for physically fit individuals, but the effects vary across studies. Divergent thinking is typically inhibited by acute, vigorous exercise, especially in nonathletes, possibly because it competes for scarce mental and physical resources. While exercising on a treadmill desk, you can do creative work. A slow walk may enhance creativity when completing creative tasks, possibly due to undemanding tasks promoting incubation periods during which mind-wandering is improved, or due to mild arousal [32].

As such, the requirement for both sleep and exercise stands in contrast to the monotonic assumption that more is always better. When creativity is pinned tightly to a desk and creators are unable to sleep or exercise, the resulting stagnation can be counterproductive. Physicists have determined that the Carnot engine - which works continuously and slowly is optimal when it comes to efficiency. Biological systems, however, are not subject to Carnot's theorem. Feedback control loops are more stable, with a degree of oscillation about a target level, rather than being fine-tuned to remain on the edge of perfection. Optimal performance comes from alternating mental and physical activity, divergent and convergent thinking, and generating and editing ideas. In many aspects of human performance, there is metaphorical systole and diastole that highlight homeostatic negative feedback loops that maintain our functioning [29].

Psychotherapy

Psychotherapy and creativity have been studied more often from the perspective of the benefits of creativity than from the reverse. The most direct link to creativity would seem to be art therapy. The primary aim of art therapy, however, is not necessary to create works that are useful to others, but rather to develop self-expression skills that facilitate patients' understanding and venting of emotions. There have been more case studies about creativity in psychoanalytic literature than in any other branch of psychiatry. Literature is one such field where psychotherapists can assist a writer through methods that are independent of how they affect the writer's neurosis or creative block. To test out ideas on the therapist, the writer would use his or her response as if it were feedback from the writer's group [29].

Cognitive training and education

Although traditional education has been used for centuries to impart creative skills, creative behaviors have only recently become explicit educational goals. In addition to providing creative motivation, traditional education can also foster emotional ties with inspirational role models. Students' emotions and behaviors are contagious when they see other students approaching a task creatively and with pleasure. Education seems to be a safer, if slower, solution than drugs as a means to enhance creativity. Although education can have unexpected side effects, many students who study to become writers end up becoming stockbrokers. In addition, traditional education can impart traditional beliefs that contribute to anchoring errors, keeping would-be creators too firmly confined to the standard model of their field [33]. Several studies have shown conflicting results regarding meditation's effects on creativity [34]. It may be because focused attention and open monitoring, the two major types of meditation, affect thinking differently. As a practitioner of focused attention meditation, you learn to concentrate on a single stimulus, like your breathing. However, as a practitioner of open-monitoring meditation, you learn to track your awareness as it sails from subject to subject. Several studies suggest that focused awareness can improve convergent thinking, while mindfulness can improve divergent thinking [35]. As a result, it is possible that alternating between the two forms of meditation will be the most effective. According to Brewer and colleagues (2011), meditation not only decreases default mode network activity but increases connectivity between major regions of the default mode, potentially increasing its efficiency.

Artistic Creativity

There is art in every culture in the world [36, 37]. However, an operational definition of art is elusive from a neuroscientific perspective. General definitions of art can be categorized as functional or procedural. Objects or occurrences that create an aesthetic experience, such as beauty, are often defined by their functional definitions of art. Besides aesthetics, functional definitions of art refer to the function of art in society. Creativity, too, is a difficult concept to define. There are two criteria for creativity: it must produce something that is innovative and it must result in something useful or applicable to a particular context [3].

Art and creativity can be defined and characterized in many ways, resulting in a broad range of potential research programs for understanding the neuroscience of art. Due to the important role of art in all cultures, neuroscientists have begun to investigate the neural systems that underline both artistic production and perception. Currently, two approaches have been used to study art in the brain. The first is to study the neural responses to art perception. The other approach involves exploring how art is created through neural processes. Despite being on opposite sides of the definitional divide, the two approaches complement each other [38].

Studies of aesthetic perception investigate how humans perceive, understand, and respond to different types of visual stimuli, how they develop preferences, and how they respond to aesthetic experiences. Artistic creativity studies analyze the processes by which people create art and explore the definition of art as a process. Despite the importance of understanding how art is perceived or experienced, this section focuses solely on the procedural aspects of art. The research on artistic creativity has been fragmented by many challenges. Further research is necessary and possible. As an examination of artists and artistic creativity in the brain will be conducted through the discussion of the latest developments in cognitive neuroscience. Several neuroimaging techniques will be reviewed. Electroencephalography (EEGs) measures the last changes in magnetic and electrical fields within the cortex. Labels of radioactive chemicals can be measured with PTE. Brain blood flow and soft issue structure can be examined with MRI and fMRI, respectively. To study creativity, MRA and fMRA have been widely used.

Studies have taken one of two approaches to understanding the impact of artistic creativity on the brain. In order to assess creativity, the first problem is to study how artistic and creative training affects the gross anatomy of the brain over the long run. By comparing artistic and non-artistic, it can be shown that brain regions that are more active in creative domains tend to differ from those in other domains. Examining the brain while it creates is another way to study creativity. In most studies of creativity, improvisation has been the primary focus because of the time constraints inherent in all methods of neuroimaging. Second, this method allows us to understand the immediate brain networks involved in a creative activity (specifically, improvisation).

Musicians have dominated studies investigating the effects of artistic training on brain structure. There are many practical reasons for this. In general, musicians begin their training at a young age, when brain plasticity is most robust, and continue their training into adulthood. Generally, professional musicians undergo the same training and practice [39]. It takes a particular set of skills to be proficient musician-fine motor coordination, practice movements, and strong auditory senses. As a model domain for examining the effects of extensive training, musical training is great because of its duration, intensity, and specificity. There has been an association between musical training and gross anatomical changes in different areas of the brain. Studies have shown differences in cerebellum volume, for example, an area associated with motor coordination [40]. The study found that these results were only seen in male musicians (not in the female group studied), and were linked to practice intensity over their lives. The primary motor areas of musicians and nonmusicians differ structurally, and these differences are often correlated with changes in primary auditory areas.

According to a 2003 study by Gaser and Schlaug, professional musicians have increased gray matter volume relative to amateurs and nonmusicians, especially in primary motor areas and somatosensory areas, premotor areas, and Heschel's gyrus (the primary auditory area) [41]. Additionally, there appears to be an increased structural and functional connectivity between auditory and motor areas in musicians as compared to non-musicians, in addition to the increased gray matter volume in auditory and motor areas. The performance of musical instruments requires auditory-motor synchronization. Studies of functional neuroimaging of creativity can help us determine what areas of the brain are active during creative processes.

Technology advances have only made it possible in the past 10 years to examine the brain during creative acts, making the neuroscience of artistic creativity an emerging field. Creative processes have also been studied about musicians, particularly jazz pianists [42].

When recording neural activity, physical restrictions are imposed on subjects. An EEG method, for example, provides precise temporal information about neural activity and can be used to provide some freedom of movement. In some situations, however, the EEG cannot provide accurate information about the origin of the electrical responses. The motion of experimental subjects must be restricted to methods such as PET and fMRI. However, these methods give data with fine spatial resolution in the brain, though the temporal resolution is several seconds behind the individual spikes of neurons (orders of magnitude greater than the individual spikes). Despite these challenges, several researchers have used fMRI to examine musicians, mainly pianists, while engaged in creative activities. Artistic creativity in fields other than music is relatively rare. In contrast to non-artists, visual artists exhibit significantly different patterns of cortical synchrony when they experience visual art [43]. The benefits of increased synchronization for artists are unclear. Dancers' EEG responses are characterized by increased alpha patterns, primarily in frontal and parietal areas, when asked to create new dances [44]. Dancers may be creative as a result of increased activity in prefrontal and parietal areas, rather than decreased activity (which is common in musicians). According to Shah and colleagues (2013), increased activity in the IFG (language areas) and orbitofrontal cortex was observed during creative brainstorming, suggesting increased frontal activity. Studying the effects of creative training on the prefrontal and parietal cortex has shown that unilateral (rather than bilateral) activation can occur [45].

The study by Saggar et al. demonstrated that drawing (in a Pictionary-like setting) decreased activity in the DMN as well as the DLPFC when compared to zigzagging drawing. Participants who were not explicitly trained in art produced this result. Though the results of existing studies of musical creativity and creativity in other areas do not always correlate, a neural network seems to be developing.

Compared to non-improvisatory tasks, musical improvisation and in some cases, visual artistic creativity increases activity in language and motor-planning areas. Additionally, improvisation was associated with deactivation throughout the prefrontal cortex.Among improvisation experts, the DLPFC activity frequently decreases during ecologically valid improvisation tasks. There is often an increase in the functional connectivity between the DLPFC and the DMN when this decrease in the DLPFC is concurrent with deactivation throughout the DMN. It has previously been observed that states of flow suppress the activation of the DLPFC. Direct sensory input is not received by the DLPFC. It is involved in controlling inappropriate actions on the top-down, which may explain its suppression during flow states. Even though DLPFC activity is suppressed in the current literature, it is important to point out that no causal relationship can be concluded from these studies, even though results can be used to suggest causality [48]. The ability to enter a flow state may be required for some types of creativity, while attention and cognitive effort are required for others. In the case of artists and their creative processes, a variety of brain regions may be suppressed, resulting in artistic creativity. Despite the numerous challenges in studying creativity and interpreting the existing results, the field has made significant progress.

Future Directions

It is still unclear what the full function of this deactivation is. There is an emerging picture of the neural systems involved in artistic (and specifically musical) improvisation, despite the varied approaches and fairly severe experimental conditions. To better understand the neural basis of artistic endeavor and creativity, neuroscientists are taking three primary directions for further research. To determine if there is a single neural system responsible for artistic creativity, a direct comparison of different types of creative expression is necessary. It is likely that there is a type of neural activity that is typified by artistic creativity, whereas mathematical or scientific creativity arises differently, depending on the domain in which you gain expertise. Considering artistic creativity to be a qualitatively and quantitatively distinct type of creativity from other forms of creativity outside of the arts may not be valid, so direct comparisons between artistic creativity and other forms of creativity outside of the arts are also essential. Additionally, studies showing the effects of training and development on artistic creativity are necessary for the future. Children who are being creative, for example, might show a different pattern of brain activity than adults who have been trained. This would indicate that training affects how the brain produces creativity. It has also been shown that deactivation in the DLPFC is associated with creativity in adults, which could suggest that hypofrontality and flow are central to creativity regardless of the level of training. Third, research is needed into the factors that influence creativity - for example, what tasks need to be accomplished or what restrictions have to be met to engage the underlying systems that are associated with creativity? In order to understand how diverse areas of the brain work together during creative expression, it might be useful to determine how the neural systems underlying creativity are modulated [29].

Bringing the Arts, Neuroscience, and Creativity Together

Studies suggest that art can impact areas of academic achievement and learning engagement as well as creative thinking and problem-solving, which have become a highlight of the call for teaching 21st-century skills. Collaboration, effective communication, innovative thinking, and creative problem-solving are among the essential career skills emphasized by organizations such as the Partnership for Twenty-first Century Schools. Teachers are increasingly being encouraged to design lessons that promote creativity [48]. The authors of Gregory et al. contend that all students should be exposed to creative thinking and problem-solving within a classroom context, not just those identified as gifted. In other words, we are assuming that creativity isn't a fixed attribute, a gift bestowed by chance [49]. It asserts that all students are capable of demonstrating innovative thinking, especially when they encounter instruction that encourages them to connect disparate concepts, apply varied solutions to problems, and apply content in new ways. Several strategies can be used to solve multi-part problems, such as collaboration and the use of graphic organizers for connecting concepts and scaffolding content, such as collaborative problem solving and the process of evaluating and revising ideas generated by others to make them better. In addition to the research already cited in this article that shows that the arts can improve student outcomes in learning and memory domains, many scientists believe that teaching with and through the arts can be a powerful way to help students think creatively and solve problems [50, 51].

By embracing and exploring new approaches to educate kids how to think creatively, educators can transform traditional, structured approaches to learning. According to Rostan, engaging in high-quality arts learning develops creativity and enhances critical thinking abilities [52]. Csikszentmihalyi emphasizes the emotional responses that the arts may elicit, leading to creative ways of thinking that "break through daily patterns and widen the spectrum of what it is to be alive" [53]. A state of flow and deep concentration can be created by the arts, leading to "ahas" in the creative thinking process. In their study, Welch and colleagues argue that to generate ideas, sketching is essential as well as generating ideas, notably in terms of design lingo. As a consequence, they encourage the development of design drawing, which allows students to create and reconstruct many types of design ideas so that they are not confined to producing a particular type of object [54]. Hetland et al. suggest that the arts help children develop more general thinking skills and dispositions, including imagining, observing, reflecting, and using multiple expression forms. According to Perkins and Arnheim, visual-thinking skills come from the arts, and they can contribute to a more creative worldview. Based on research on cognition, Perkins makes an argument that the arts can motivate and engage students in all subject areas by cultivating reflective thinking. When looking at art, one develops a set of skills. He refers to these abilities as reflective intelligence, or awareness of chances to employ such abilities, as well as a willingness to do so. In the study collection Critical Links: Learning in the Arts and Student Academic and Social Development, Deasy reports on several studies that show the benefits of learning in the arts for general learning in non-arts disciplines. Among these are self-motivation, social skills, tolerance, empathy, and persistence. The arts, according to Posner and Patoine, help to sustain attention, which bolsters attentional networks in the brain, thus improving learning. In addition, others have studied the arts through the lens of neuroscience to better understand how the arts may impact creativity and cause brain changes. In Dunbar's study, more activity was seen in the left frontal lobe in students who took part in performing arts activities compared to those who did not, which is Often related to higher-order mental processing.

Dunbar's study is the first to compare students performing arts with students who are not performing arts. Using fMRI, researchers measured task-related BOLD (blood oxygenation level dependent) imaging responses when participants were asked to judge how objects should be used without regard to the materials used. According to Figure 1a and 1b, there is a difference in activation levels between performing arts groups and those who are not involved in performing arts. In the non-performing arts majors, the regions in the medial fusiform gyri were selectively activated during the Uses of Objects task, but not in the performing arts majors. The left inferior frontal gyrus and left superior frontal gyrus were both more active in performing arts majors. Studies on word generation tasks have shown that the inferior frontal gyrus of the left brain plays a role in generating names. Students in the performing arts showed increased activation in this area, which suggests they are focusing on the task in a linguistic manner, whereas the non-performing arts students are focusing on the task in a more perceptual manner. Among their three groups of students (music, theater, and controls) their behavioral tasks revealed significant differences in working memory. Additionally, their DNA genotyping results may indicate that their performing arts students and controls may have different genetic profiles (in MAOA and COMT). Moreover, Dunbar found that students with prior experience in the performing arts were more likely to produce creative ideas than their peers with no performing arts background [55].

Music training has also been shown to alter brain anatomy associated with auditory and motor processing, stress, and emotion regulation by initiating reflexive brainstem responses, and regulation of emotion and arousal. According to Jung et al., there may be anatomical changes in the parietal lobe that correlate with creative performance: tasks that require divergent thinking. A research study conducted by Limb and Braun found spontaneous, creative improvisation activated parts of the brain differently from memorized performance. They examined the brain activity of jazz musicians while they played improvisational jazz compared to memorizing jazz selections. Student participants in improvisational jazz and theater groups were found to produce more novel ideas than non-arts peers by Sawyer. According to Kraus, playing an instrument is associated with improving speech processing and interpreting voice changes that are associated with language comprehension. A thorough review of neuroanatomical changes related to creative endeavors reveals how the arts can promote growth and learning (for more information, see [46, 29]. These studies, along with an increasing body of literature on the relationship between arts and creative thinking, suggest that involvement in the visual and performing arts can assist in the sustained maintenance of attention, the enhancement of memory, the creation of emotional connections with the content, and the promotion of creativity. Concentration can lead to "aha" discoveries, and multiple, divergent solutions can prove useful in solving problems [47].

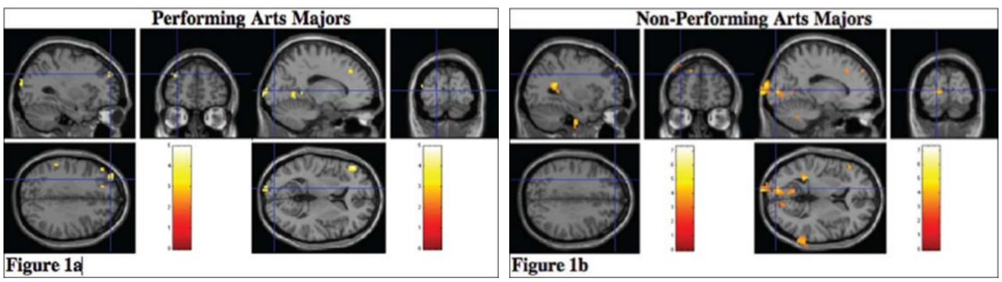

Figure 1a, 1b. Differences in activation levels between the performing arts and non-performing arts groups

Conclusion

Currently, we do not completely understand the neuroanatomical correlation of creativity. Researchers are still in a very early stage of understanding these processes. There is a question of whether the observed differences in the brains of highly creative people are the result of or the cause of their creative ability. It is necessary and important to have creativity in order to live successfully in a world where we don't know all the answers, a world we are still exploring. We can recognize and develop effective treatment and rehabilitation strategies for those who struggle with creative activity by understanding the neurological underpinnings. It is essential that we create a culture that values creativity and values innovation because if we desire to increase creativity and innovation we need time in our lives and society for simply being so that our minds can reach new heights of achievement they would have missed otherwise.

Despite the numerous hurdles associated with studying creativity and interpreting previous findings, the science has made great progress. Although previous research has taken a variety of methodologies and subjected participants to a variety of experimental conditions, a rather consistent picture of the brain systems involved in artistic improvisation is developing.

Educators today face the challenge of preparing students who are innovative, creative, and problem-solvers in order to meet the demands of the global marketplace. Industries are looking for employees with abilities that go beyond subject knowledge in all sectors, but especially in the fields of Science, Technology, Engineering, and Mathematical Sciences (STEM). Professionals must be innovative, flexible, adaptable, and collaborative as part of their 21st-century talents. The arts, as indicated in this article, aid in the development of certain abilities, insights, and attitudes for the twenty-first century. Overall, arts education and arts integration-teaching with and through the arts may impede students' preparation for the global workforce. With case studies of artists with neurological diseases and their experiences with their disease, wee review the construct of creativity, describe the neural mechanisms underlying these effects, and explain the influences of art on creativity.

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