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3. BRAIN AND CREATIVITY

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Abstract: *Great ideas seem to come out of nowhere. Now we are one step closer to understanding how they appear. The areas responsible for language and creativity are thought to compete in the brain, which may explain why some people with brain damage suddenly become artists. Originality - or the ability to think of new ideas that do not occur to many people - is the key aspect of creativity. Researchers are trying to determine the mechanism by which originality is established. While creativity is generated by the right hemisphere of the brain, it is suppressed by language-specific processes in the left hemisphere: "Language regions may compete with the right hemisphere's ability to produce creative ideas." This would explain why when areas responsible for language processing are affected, originality appears to increase. A brilliant idea is not enough to qualify a person as creative. Creativity is among the human characteristics whose mysteries we are still trying to understand. It seems almost impossible to find a clear definition for it, and it is equally difficult to look for its origins in the human brain. Many researchers define creativity as a special performance that is both new and appropriate. If we look at creativity as a concept rather than a trait, a number of factors must be considered. For example, an ingenious idea must be realized in such a way that it is visible and useful to others. Only a person who succeeds in this can truly be called creative.*

Creativity is a complex process that requires the activation of several areas of the brain. So far it is not clear whether creativity requires a specific neural architecture or not. At the root of all thoughts, emotions and behaviors is communication between neurons. Brain waves are the products of synchronized electrical impulses resulting from the communication of masses of neurons. The speed of brain waves is measured in Hz and are divided into categories that delineate slow, moderate and fast waves. They change according to activities or feelings. The electroencephalograph measures brain waves of different frequencies in the brain by using sensors placed on the scalp, the frequency representing the recurrence of a wave in one second. If any of these frequencies are deficient, excessive or difficult to access, psychic performance can suffer. Learning about brain waves and brain wave frequencies is key to understanding how to navigate and reprogram the mind, and to access deeper levels of consciousness. In neuroscience, there are five distinct brainwave frequencies, namely Beta waves, Alpha waves, Theta waves, Delta waves, and Gamma waves. Each frequency has its own set of characteristics representing a specific level of brain activity and a corresponding unique state of consciousness.

Key words: *creativity, brain, language, brain waves, consciousness*

1. Introduction

Great ideas seem to come out of nowhere. Now we are one step closer to understanding how they appear. The areas responsible for language and creativity are thought to compete in the brain, which may explain why some people with brain damage suddenly become artists. Originality – or the ability to think of new ideas that do not occur to many people – is the key aspect of creativity. Researchers are trying to determine the mechanism how originality is established. "We are amazed by the contradictory results in the literature," says Simone Shamay-Tsoory of the University of Haifa, Israel. To better pinpoint the areas involved in creativity, Simone and other scientists compared 40 patients with lesions in one of three distinct brain areas with a group of individuals without brain lesions.

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While their brains were being scanned, the two groups were each given a piece of paper with 30 identical circles on it and the task was to draw as many (meaningful) objects as they could within five minutes. The volunteers were graded based on the total number of responses and the rare responses given (under statistical aspect), taking into account the previous responses of the healthy volunteers. The test measured creative thinking – the ability to generate new ideas that provide new solutions to a particular problem.

Although the research could not assess the creativity level of the subjects before the brain injury, the results showed that the level of originality is strictly related to the brain area of the injury. Those who had clearly superior results compared to the healthy subjects had lesions in the left hemisphere of the brain, in the areas responsible for language processing. Those who had the lowest scores had lesions in the right hemisphere of the brain, in the area involved in planning and decision-making. Shamay-Tsoory believes that while creativity is generated by the right hemisphere of the brain, it is suppressed by language-specific processes in the left hemisphere: "Language regions may compete with the right hemisphere's ability to produce creative ideas." This would explain why when areas responsible for language processing are affected, originality appears to increase.

Rex Jung of the Center for Mind Research in Albuquerque, New Mexico, tells us that this is the first time that brain lesions have been used to search the origins of creativity. However, "creativity is not a thing", believes Arne Dietrich of the American University of Beirut, Lebanon, and "it is distributed over a large part of the brain"[284]. It all started with the patient W. J., a war veteran whose epileptic seizures had become so severe that it was almost impossible for him to have a normal life.

W. J. was willing to try anything to stop these seizures, including trying a rare procedure: an surgery cutting through an important commissure, called the corpus callosum, that connects the two cerebral hemispheres in humans and other mammals. In the past, this procedure had been successful for several other patients, managing to reduce the number of seizures without producing adverse effects. Fortunately, in the case of W. J. the surgery was successful.

His grand mal seizures (seizures involving severe convulsions and loss of consciousness) disappeared entirely, his quality of life improved considerably, and his intelligence and personality remained intact after the procedure. Although W. J. had reported no major changes in daily life other than feeling better than ever, some researchers continued to question the possible consequences of the surgery. Because the corpus callosum is made up of bundles of myelinated axons, severing it essentially cuts off a communication pathway between the two cerebral hemispheres.

These axons are extensions of neurons (a neuron usually has only one axon) and, together with dendrites, make synapses possible: the nerve signal reaching the end of a neuron's axon causes the release of substances called neurotransmitters, which can generate a new nerve signal on the dendrites of another nearby neuron. Myelin forms an insulating sheath around axons, ensuring increased nerve signal

[284] Gazzaniga, Bogen, & Sperry, *Some functional effects of sectioning the cerebral commissures in man*, 1962, Proc Natl Acad Sci U S A. 1962 Oct; 48 (10): 1765–1769, doi: 10.1073/pnas.48.10.1765

speed. It would have been quite unusual, then, for this disruption of communication through the corpus callosum to produce no cognitive or behavioral changes. Indeed, on a closer look, in the behavior of W. J., some bizarre changes could be observed. His wife had seen him, on several occasions, do contradictory things: if he picked up an object with his right hand, he immediately put it back with his left hand.

However, countless experiments were needed to clarify the nature and extent of these changes. If, before surgery, W. J. was able to write intelligible words using his left hand (he was right-handed), after the surgery this had become practically impossible. When touched a certain number of times on a certain part of the body, he could only reproduce the number of touches by using the hand on the same part of the body.

”Overall, what these experiments showed quite clearly was that W. J. could give correct answers only when both stimulus and response depended on the same half of the body”[285]. The explanation for these results was simple. Because each hemisphere communicates with the opposite side of the body (the left hemisphere with the right side, and the right hemisphere with the left side), without the corpus callosum, information processed by the left hemisphere could not be accessed by the right hemisphere and vice versa.

The experiments continued. Both W. J. and other patients who subsequently underwent similar interventions gave researchers countless opportunities to see how the two “disconnected” hemispheres behaved in more complex tasks, using a highly ingenious method devised by Michael Gazzaniga. Due to an anatomical peculiarity of the optic nerve (consisting of axons through which the retina communicates with other structures in the nervous system), an image presented in the left half of the visual field is processed by nerve structures in the right hemisphere, and vice versa.

If, before the surgery, the patients could easily recognize images presented anywhere in their visual field, after the surgery, they confidently said that they did not see anything when the image was presented to them in the left half. However, something surprisinghappened when they were asked to respond non-verbally to these questions: ”although they continued to say that they did not see anything, they correctly pointed with their left hand to the object presented in the picture”[286]. In other words, if the researchers wanted a correct response from the right hemisphere, they did not ask the patient to respond with words, but with gestures!

Performance in other tasks also seemed to depend on the hemisphere that processed the stimulus. A problem that required the use of logic (for example, a mathematical calculation problem) was only solved correctly when presented to the left hemisphere, not when presented to the right. A visual-spatial problem (e.g., arranging cubes) was solved correctly when presented to the right hemisphere, but not when presented to the left one[287]. Each hemisphere thus appeared to have an advantage in certain tasks and a disadvantage in others.

[285] Gazzaniga, Bogen, & Sperry, op. cit.
[286] Gazzaniga, Michael S., (1967). *The split brain in man.* ”Scientific American”, *217* (2), 24–29. https://doi.org/10.1038/scientificamerican0867-24
[287] Ibidem

2. The origin of the myth

All these results seemed to confirm the conceptions regarding the brain already popular at the time. Some were scientifically based. For example, the idea that the left hemisphere is dominant for language was not new: "since the 19th century it has been observed that lesions of the left hemisphere generated language deficits"[288]. Others, however, were not scientifically grounded. Since the left hemisphere controls the right hand (the dominant hand, in most cases), the left hemisphere was thought to be superior to the right hemisphere, being the "rational" one[289]. No surprise, then, that the left hemisphere is better at solving tasks that require logic!

The mass meda told the story of these studies with great enthusiasm, especially since Roger W. Sperry, one of the researchers who initiated this type of studies, called "split-brain", won the Nobel Prize in Physiology or Medicine in 1981. The enthusiasm, however, gave rise to generalizations that the researchers never made: if the left hemisphere is "analytical", the right one should be "creative", and if the left hemisphere is "logical", the right should be "emotional"[290].

3. Reasoning and creativity

Perhaps the generalizations were premature, but does that mean they were also wrong? Firstly, we need to look more closely at the initial studies. What was not discussed in the mass media, but was mentioned in the scientific articles, is that the patients tested did not perform identically in the experiments, with some of them doing better than others. Also, certain language tasks (those not involving syntax) could also be solved correctly when presented to the right hemisphere, to an extent that Michael Gazzaniga himself considered this "impressive".

Moreover, one of these patients developed 13 years after the surgery the ability to respond verbally and to the stimuli presented to the right hemisphere[291]! Secondly, certain cases, later described by other researchers, performed quite unexpectedly in similar tasks. For example, one patient could only respond correctly in writing when the task was presented to the right hemisphere, not to the left one, as would be expected based on previous studies[292]. All this suggests the existence of individual variations, but also a remarkable plasticity that would allow one hemisphere to take over the functions of the other.

How can we tell if reasoning and creativity really depend on different hemispheres? We need studies involving more, healthy participants, and methods that allow us to measure brain activity, to check to what extent the generalizations are founded or not. For example, a functional magnetic resonance imaging (fMRI) study showed that deductive reasoning involves increased activity in structures in both brain hemispheres.

Only at certain stages of this type of reasoning there is a greater increase in

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[288] Berker, E. A., Berker, A. H., & Smith, A. (1986). *Translation of Broca's 1865 report: Localization of speech in the third left frontal convolution. "*Archives of Neurology", 43 (10), 1065–1072. https://doi.org/10.1001/archneur.1986.00520100069017

[289] Michael C Corballis, Paul M Corballis, *Can the mind be split? A historical introduction, Neuropsychologia*. 2021 Dec 10:163:108041. doi: 10.1016/j.neuropsychologia.2021.108041. Epub 2021 Sep 25

[290] Pines, M. (1973, September 9). *Two astonishingly different persons inhabit our heads*. Retrieved from http://www.nytimes.com/1973/09/09/archives/we-are-leftbrained-or-rightbrainedtwo-astonishingly-different.htm

[291] Gazzaniga, M. S. (1998). *The mind's past.* University of California Press

[292] Ibidem

activity in neural structures in the right hemisphere, not the left, as expected[293]. And verbal analogies appear to involve increased activity in the structures of both hemispheres. Regarding creative thinking, it has been repeatedly shown to involve an extensive network of neural structures in both hemispheres, not just the right hemisphere[294]. Even when we specifically measure visual creativity we do not find a different pattern. Even language, which seemed so clearly dependent on the left hemisphere in split-brain studies, appears to involve a multitude of cortical areas in both hemispheres. For example, electrical stimulation of areas in the right hemisphere "short-circuits" language production, with individuals temporarily losing their ability to speak[295].

Can we therefore consider this idea a myth? We have no clear evidence for either reasoning or creativity that they are specific to a single hemisphere. We have no evidence that a more "active" hemisphere is associated with better logic or increased creativity. And, of course, we have no evidence that we can "train" our right hemisphere to become more creative, whatever the books or apps that offer exercises to develop your "right brain" may promise.

Maybe you are "right-wing", creative, artistic, a thinker with an open mind, who perceives things from a subjective point of view. Or, maybe "you're from the left", more analytical, good with details and more logical. At least that's how it was until now. It seems that this idea of how the brain works has become a mere figure of speech.

Researchers have found that these personality traits may have nothing to do with which part of the brain you use more. Through brain scanning it was found out that both parts of the brain are used, to the same extent, by all people. "It is true that certain functions take place in only one part. Language tends to be on the left, attention more on the right. But humans don't have stronger neural networks on one side at the expense of the other. Rather, it is determined step by step, connection by connection," said Dr. Jeff Anderson, researcher of the University of Utah, USA.

Over a thousand people between the ages of 7 and 29 participated in this study. All participants had their brains scanned in a state of rest, for five to ten minutes. The researchers were looking for something called "lateralization," the idea that certain mental processes occur only in a certain hemisphere of the brain, the left or the right. They divided the brain into 7,000 regions to see if the connections between the regions were "lateralized" to the left or right.

"We need to understand the personality types associated with the terminology "left" or "right". However, we found no patterns in right-hemisphere or left-hemisphere connections attributed to a particular personality. Perhaps personality types are not related to which hemisphere is more active, stronger or with more connections", concludes Jared Nielsen, an expert in neuroscience, for "Huffington Post".

A new brain imaging study by researchers of Drexel University in Philadelphia sheds light on this controversy by studying the brain activity of jazz

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[293] Fangmeier, T., Knauff, M., Ruff, C. C., & Sloutsky, V. (2006). fMRI *Evidence for a Three-Stage Model of Deductive Reasoning*. "Journal of Cognitive Neuroscience", 18 (3), 320–334. https://doi.org/10.1162/jocn.2006.18.3.320

[294] Arne Dietrich 1, Riam Kanso *A review of EEG, ERP, and neuroimaging studies of creativity and insight*, Psychol Bull. 2010 Sep;136 (5):822-48. doi: 10.1037/a0019749

[295] Penfield & Roberts, *Speech and Brain Mechanisms*, Collections: Princeton Legacy Library, Hardcover, 2014

guitarists during improvisation.
The study, which was recently published in the journal NeuroImage[296], showed that the creativity process occurs primarily in the right hemisphere in musicians who are relatively inexperienced in improvisation. However, musicians with extensive improvisational experience rely primarily on the left hemisphere of the brain. This suggests that, in reality, creativity is a "right-hemisphere ability" when a person is faced with an unfamiliar situation, but this process relies on well-learned, left-hemisphere routines when a person has experience with the respective situation.

4. Creativity can be born in both hemispheres, depending on personal experience

By considering how brain activity changes with experience, this research may help develop new methods to train people to be creative in their field. For example, when a person is an expert, his performance is produced primarily by relatively unconscious, automatic processes that are difficult to consciously alter but easy to disrupt during testing, as when self-awareness causes a person to get stuck and fail to do what he set out to do.

In contrast, novice performances tend to be under deliberate and conscious control. Thus, they are better able to make adjustments according to the instructions given by a teacher or a coach. Recordings of brain activity could reveal the point at which a performer is ready to set aside some conscious control and rely on unconscious, well-learned routines. Releasing this conscious control prematurely can cause the performer to block a harmful habit or an inappropriate technique.

The research team recorded high-density electroencephalograms (EEGs) of 32 jazz guitarists, some of whom were very experienced and others who had little experience in the field. Each musician improvised 6 jazz pieces accompanied by a programmed piano, bass and drums. The 192 recorded improvisations were later played by four expert jazz musicians and teachers so that they could evaluate each piece for creativity and other qualities.

The researchers compared EEGs recorded during highly rated performances with the EEGs recorded during performances that were considered less creative. For highly valued performances compared to less valued performances, there was greater activity in posterior areas of the left hemisphere of the brain; for lower-rated performers, there was greater activity in right-hemisphere areas, mostly in the frontal area.

As they are, these results might suggest that highly creative performances are associated with posterior left hemisphere areas and that less creative performances are associated with right hemisphere areas. This model is misleading, however, according to the researchers, because it does not take into account the musician's experience.

Some of these musicians were extremely experienced, giving numerous performances over time. Other musicians were much less experienced, giving only a very small number of performances up to the date of the study. When the researchers reanalyzed the EEGs to statistically observe the experience level of the performers, a very different pattern of results emerged. Virtually all the differences

[296] Neuroimage: Reports | Journal | ScienceDirect.com by Elsevier, consultat la 27.11.2023

between highly creative and less creative performances were found in the right hemisphere, especially in the frontal region.

The new study reveals the areas of the brain that support creative musical improvisation for highly experienced musicians and their less experienced counterparts, and addresses the controversial issue of the roles of the left and right hemispheres in creativity. Moreover, it raises an important issue that lies at the heart of defining and understanding creativity. If creativity is defined in terms of the quality of a product, such as a song, an invention, a poem or a painting, then the left hemisphere plays a key role, the researchers believe. But if creativity is understood as a person's ability to cope with novel, unfamiliar situations, as in the case of novice improvisers, then the right hemisphere plays the main role.

5. Memory should be the seat of creativity

Since the beginning of the 2000s, researchers from the University of Florida School of Medicine have claimed that innovation and creative thinking would be characteristic of people who are able to store a lot of specialized knowledge in the temporal and parietal lobes of the brain and operate on it through the lobes frontal, producing what is called divergent thinking. It went even further, showing the way in which information is stored by the various areas of the brain depending on its age. Thus, the temporal and parietal lobes are responsible for its storage up to 30 days after acquisition, and the parietal lobe becomes the seat of memory 60 days after acquisition.

Recent studies by the University of Graz and College London, using MRI, have confirmed this hypothesis, demonstrating that when we generate new, creative ideas, we use the same network in the brain, through which we remember life episodes or try to predict the future. Basically, the information stored in the brain is updated and recombined in a new way, and we use this process either when we want to simulate the possible future, or when we invent or create something. Another study carried out at the University of Iowa linked creativity to memory even more, showing that amnesic patients, due to trauma to the critical area in the brain for memory – called the hippocampus – have low scores on creativity tests. So: Imagination/creativity is dependent on our knowledge and experiences and our ability to store and recall them.

And from a chemical point of view, memory and creativity are linked. Thus, the neurotransmitter dopamine proved to be essential both in learning and remembering, but also in creativity. Dopamine is essential in the formation of memories, it leads to plastic changes in the brain, as a result of learning. However, it is also increased in some diseases such as mania and schizophrenia, characterized by unconventional thinking (by the way, many artists have suffered from manic-depressive illness) and the drugs that treat these diseases decrease creativity.

Some drugs, such as amphetamine and cocaine, are frequently taken by artists because they stimulate their creativity, these drugs act in the brain by increasing dopamine. People open to new ideas have modified genes that regulate dopamine activity and have a more plastic brain, so they learn more easily, adapt faster.

Several psychology studies have discovered an interesting aspect, that students who spend part of their time on study trips abroad become more creative.

Creativity increases the longer they stayed there and adapted better to the local culture. On their return, they have a new perspective on many things and become more creative, according to creativity tests. In fact, writers have known this trick for a long time; they used to go on "documentation" trips, because they noticed that they were more productive in writing when they returned from such trips.

It was speculated that the explanation of this phenomenon would consist in the plastic changes produced in the brain by the exposure to new things. It is known from animal studies that exposure to the new things stimulates learning and changes the connections in the brain. Rats that are kept for several weeks in so-called enriched environments (where they can explore, have toys to interact with, and meet strange rats) later become better able to learn new things, their brains temporarily switching to a mode of accelerated learning.

So the life experiences and the knowledge we learn, modify our brain, create new synapses and thus contact information in a new way. A reshaped brain sees the same things differently, is able to create new and innovative information. Bombardment with information physically changes our brain, and the brain thus changed becomes a new brain, capable of new things. A brilliant idea is not enough to qualify a person as creative.

Creativity is among the human characteristics whose mysteries we are still trying to understand. It seems almost impossible to find a clear definition for it, and it is equally difficult to look for its origins in the human brain. Many researchers define creativity as a special performance that is both new and appropriate. If we look at creativity as a concept rather than a trait, a number of factors must be considered. For example, an ingenious idea must be carried out in such a way that it is visible and useful to others. Only a person who succeeds in this can truly be called creative.

6. The evolution of creative ideas

In 1926, the English sociologist and psychologist Graham Wallas introduced a theory about how a creative process develops. According to him, there are five essential steps. First, a person can only have creative ideas through study and exercise in that field, such as painting or literature: a step Wallas calls training. Only a prepared mind can reach the next stage. During the incubation period, an idea forms in the brain and blossoms without being consciously noticed. "The brain's resting-mode network, called the Default Mode Network (DMN), is responsible for the incubation of an idea,"[297] explains neuroscientist Konrad Lehmann of the Friedrich Schiller University in the German city of Jena. "These regions are highly active when we are doing nothing – for example, when we are relaxing or daydreaming."

Then, when the mind is occupied with something else, the instant inspiration reaches the level of consciousness. Wallas calls this stage enlightenment, preceded by anticipation. "Researchers have found that the right lobe of the brain is very active when a new idea suddenly appears,"[298] says Lehmann. "An intense activity

[297] *În căutarea creativității* – DW – 07.12.2017, https://www.dw.com/ro/%C3%AEn-c%C4%83utarea-creativit%C4%83%C8%9Bii/a-41694111, consultat la 12.12.2023
[298] *În căutarea creativității* – DW – 07.12.2017, 15

of the left lobe follows: verification takes place, the last stage of the creative process. The idea is concretized and revealed to the outside world."

Creativity isn't just genetic – it can be acquired. Certain personality types are more associated with creativity than others. Psychologists and neuroscientists have concluded that people with an open attitude towards new experiences are usually more creative: they are curious, have a rich imagination and question even seemingly certain things. It is not only curiosity and imagination that are associated with creativity. They say that madness and creativity often go hand in hand. How much truth is behind this concept?

"According to some studies, relatives of someone suffering from a mental disorder are often unusually creative,"[299] explains Lehmann. "But one cannot say that someone is either in a mentally ill state or in a healthy state. Not everything is black or white, shades of gray dominate. Somewhere in this gray area you can find a person who is more creative than most, with a predisposition to mental disorders."[300] The neurologist added that at a certain point, the mental illness takes over and "it becomes impossible for the person to formulate their ideas coherently."

A condition associated with creativity is bipolar disorder, also known as manic-depressive syndrome. Affected people go through periods of euphoria, followed by depression. The euphoric period, "mania", can last for months and is characterized by hyperactivity. In these phases, the person can undertake many creative activities, but in the depression phase he can hardly concentrate on them.

"It is known that the famous German composer Robert Schumann suffered from bipolar disorder. He composed much more in mania than in depression,"[301] says Lehmann. But the compositions of the period of depression are not inferior to those of the period of mania. Of course, a person can be creative without being mentally unstable. "Anyone can be creative up to a certain point"[302], is the opinion of the German neurologist. Maybe not quite like Leonardo da Vinci, but it's already a start to be able to cook good food!

7. How to "manipulate" our brain

In professions that require a high degree of creativity, everyone knows the feeling of inner emptiness caused by a lack of ideas. There are two methods of reactivation in these situations. First: you just have to get down to business. Regions of the brain, already trained in that area, will begin the process of scanning and sorting the information, which will trigger a lot of activities that lead to a creative idea.

Another method is the exact opposite: you try to document yourself about the problem, you find some solutions, but then you leave the notes, go for a walk or go to bed. "You're basically manipulating your brain, hoping to activate the sleep mode network and let it do its thing," concludes Lehmann. Creativity is a complex process that requires the activation of several areas of the brain. So far it is not clear whether creativity requires a specific neural architecture or not. The research team of the cognitive neurologist Roger Beaty of Harvard University seems to have found

[299] *În căutarea creativității* – DW – 07.12.2017, 16
[300] Idem, 17
[301] Idem, 18
[302] Idem, 19

differences in the brains of extremely creative people.

His investigations revealed three neural networks with strong connections involved in the creativity process in the parietal and prefrontal cortices. This study began to identify the processes of controlled thought and spontaneous ideas. Everything seems to indicate that a person's creativity might be predictable from the strength of their neural connections in these three networks. According to this study, creativity or creative thinking would involve three different neural networks working at the same time. These are the following:

Default or predetermined neural network

It is the one involved in the processes of imagination, in dreaming or when our mind wanders without an object of attention. It is distributed in the middle area of the temporal, parietal and prefrontal lobes. It seems that they could develop a fundamental role in the generation of ideas and possible solutions for their execution.

Executive control network

It is related to the evaluation of ideas to determine whether they correspond to the creative objective. It is a set of regions that are activated when we need to control thought processes or focus our attention. Includes the anterior cingulate gyrus.

The relevant neural network

This network is intended to alternate between predetermined and executive control networks. Our brains organize the stimuli we receive through our senses into what we might call “blocks of information”. Every time we receive new information, new neural networks are created that are immediately connected to the existing information. It creates mental models from which we can easily extract the information we need to solve problems that may arise later.

The problem is that while they are very useful for solving tasks without much prior analysis, some of these blocks become so rigid that they are very difficult to modify. Creativity leads to challenging those rigid neural networks to lead to creative and imaginative thinking. In a 2014 study, researchers of Stanford, USA, proved that walking improves creativity. Moreover, the simple act of going for walks is known to relieve stress and contribute to cardiovascular health.

In addition, research has shown that while walking the person is more creative, and this stimulation of the brain to be more creative lasts a little longer even after the movement stops. Another interesting finding is that walking boosts creativity, whether you're moving indoors or outdoors. Thus, it has been observed that the movement itself is the reason for stimulating creativity and not the environment.

Moreover, one of the tests carried out in the study showed that a person who walks is twice as creative as someone who sits down. For people with diabetes who have foot complications such as diabetic neuropathy or diabetic foot, it can be an extra motivation to go for walks outside or even indoors. These people are advised to have an active lifestyle to care for their feet and reduce the risk of amputations.

8. Brain waves

At the root of all thoughts, emotions and behaviors is communication between neurons. Brain waves are the products of synchronized electrical impulses resulting

from the communication of masses of neurons. The speed of brain waves is measured in Hz and these are divided into categories that delineate slow, moderate and fast waves. They change according to activities or feelings. The electroencephalograph measures brain waves of different frequencies in the brain by using sensors placed on the scalp, the frequency representing the recurrence of a wave in one second. If any of these frequencies are deficient, excessive or difficult to access, psychic performance can suffer.

Learning about brain waves and brain wave frequencies is key to understanding how to navigate and reprogram the mind, and to access deeper levels of consciousness. In neuroscience, there are five distinct brainwave frequencies, namely Beta waves, Alpha waves, Theta waves, Delta waves, and Gamma waves. Each frequency has its own set of characteristics representing a specific level of brain activity and a corresponding unique state of consciousness[303].

The lowest frequencies are delta frequencies. They are less than 4 Hz and occur in deep sleep and some abnormal processes. It is the dominant rhythm in infants up to one year of age and is present in stages 3 and 4 of sleep. Increasing Delta waves can have the effect of diminishing awareness of the physical world and accessing information from the unconscious mind. They decrease when high focus is required. However, most people diagnosed with attention deficit disorder experience increases rather than decreases in Delta activity when trying to focus, as it often severely restricts the ability to focus and maintain attention.[304]

The next brain wave is the theta wave. Theta activity has a frequency of 3.5 to 7.5 Hz and is classified as "slow" activity. It is associated with creativity, intuition, daydreaming and is a repository for memories, emotions and sensations. Theta waves are powerful during internal focus, meditation, prayer, and spiritual awareness. It reflects the state between wakefulness and sleep and refers to the subconscious mind. Theta is thought to reflect activity in the limbic system and hippocampal regions. When the theta rhythm appears to function normally, it mediates and/or promotes adaptive, complex behaviors such as learning and memory. In unusual emotional circumstances, such as states of stress or illness, there can be an imbalance of the three major transmitter systems, leading to abnormal behavior.[305]

Alpha waves are those between 8 and 12 Hz. A healthy alpha wave production promotes mental resources, aids mental coordination and lessens the general feeling of fatigue. When Alpha predominates, most people feel at ease and relaxed. Alpha seems to be the threshold of connection between the conscious and the subconscious. It is the predominant rhythm seen in adults in a normal resting state - it is present for most of life, especially after the age of thirteen. Alpha is a common state for the brain and occurs whenever a person is alert but not actively processing information. They are stronger over the occipital cortex and also over the frontal cortex.[306] Alpha waves have been associated with extroversion, creativity and mental work. Alpha is one of the brain's most important frequencies in the process

[303] Fields, R. D. (2020). *Electric Brain: How the New Science of Brainwaves Reads Minds, Tells Us How We Learn, and Helps Us Change for the Better.* BenBella Books
[304] Idem, 21
[305] Idem, 22
[306] Fields, R. D., op. cit., 23

of learning and using information and allows for easy switching from one task to another.

Beta activity is “fast” activity. It has a frequency of 12 Hz and higher. It reflects active desynchronized brain tissue. It is usually seen on both sides in a symmetrical distribution and is most obvious frontally. It may be absent or reduced in areas of cortical damage. It is generally considered a normal rhythm and is the dominant rhythm in those who are very alert or anxious.[307] It is the state in which most of the brain is when we have our eyes open and listen and think during analytical problem solving, judgment, decision making, processing information about the world around us.

Gamma is measured between 30 and 44 (Hz) and is the only frequency group identified in every part of the brain. When the brain must simultaneously process information from different areas, it is assumed that the 40Hz activity strengthens the areas required for simultaneous processing. Good memory is associated with a well-regulated and an efficient 40Hz activity, while a 40Hz deficiency creates learning disabilities.

9. Conclusions

If you were to hold a brain in your hands, the first thing you would notice would be its symmetry. You would notice the two cerebral hemispheres that make up the “big brain”, then the two cerebellar hemispheres that make up the cerebellum, also called the “small brain”. If you tried to separate the hemispheres, you couldn't, because they are connected by special structures called commissures. You might be wondering what all these things mean? Why do we have pairs of hemispheres and not a single, uniform brain?

A widely circulated answer in the press is this: the two cerebral hemispheres perform different functions. The left hemisphere is the “analytical”, rational, logical brain that “thinks” in words. The right hemisphere is the “creative brain”, the one that makes imagination and intuition possible, that “thinks” in pictures. So, if you wanted to recruit the best engineers, it would be enough to find out which candidates are “more active” in the left hemisphere, and if you were looking for the best musicians, you would only need to know which are the ones in the case of which the right hemisphere is “more active”. But is our brain that simple?

How can we tell if reasoning and creativity really depend on different hemispheres? We need studies involving more, healthy participants, and methods that allow us to measure brain activity, to check to what extent the generalizations are founded or not. For example, a functional magnetic resonance imaging (fMRI) study showed that deductive reasoning involves increased activity in structures in both brain hemispheres.

No one can dispute that the studies that spawned this myth are spectacular and that they left a strong impression on those who read about them. But what we mean by “analytical” or “creative” usually refers to more complex processes than solving an equation or arranging cubes. The analytical-creative dichotomy itself may be wrong: just as solving a problem can require creativity, creativity can also require deductive reasoning. As I have shown above, we have no reason to believe

[307] Fields, R. D., op. cit., 24

that we have an “analytical brain” and a “creative brain”. But one brain, complex and spectacular, which we are still struggling to understand.

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