

CONNECTING THE DOTS: YOUR BRAIN AND CREATIVITY

Dita Cavdarbasha¹ and Jake Kurczek^{2,3*}

¹Haverford College, Haverford, PA, USA, ²Department of Psychology, Loras College, Dubuque, IA, USA, ³Department of Neuroscience, Loras College, Dubuque, IA, USA

REVIEWED BY:



AMALIA
14 YEARS OLD

Have you ever taken the opportunity to marvel at an intricate painting, relax to a delicate piece of music, or ponder a complex poem? Humans pursue creative expression and enjoy creatively produced material every day. Creativity is essential for the arts, for new inventions, and for human expression. How does the brain support creativity? While creativity is all around us and a fundamental aspect of our lives, asking scientific questions about creativity has been difficult. While we can identify creative acts and processes, there has been some trouble testing and measuring creativity. Here, we explore the scientific research of creativity. In particular, we ask what is happening in the brain and in our thoughts in order for us to pursue creative activities. Finally, we explore some myths surrounding the brain and creativity and the benefits that being creative has in your life.

Creativity is just connecting things. When you ask creative people how they did something, they feel a little guilty because they didn't really do it, they just saw something. It seemed obvious to them after a while—Steve Jobs

WHAT IS CREATIVITY?

Creativity has long fascinated everyone from artists to philosophers to psychologists. Why do humans feel the need to be creative and enjoy creative material? While creativity is a basic part of human thinking, what counts as creativity and how do we measure it? Creativity is often viewed as a **subjective** field, meaning that everyone's personal opinion about creativity is different, so we need to have a really clear definition in order to understand what creativity is. So, what exactly is creativity? While there are many components of creativity, including originality, pleasure, value, process, and imagination, the definition that scientists use to study creativity puts those components together to say that creativity is an ability to produce something that is both novel (or original) and has utility (is valuable to someone). This definition allows scientists to develop of testable hypotheses about how creativity arises from the human brain.

SUBJECTIVE

Based on personal opinions, interpretations, points of view, emotions, and judgment. The opposite of subjective information is objective information—analysis that is fact-based, measurable, and observable.

HOW DO WE DEFINE CREATIVITY?

We all interact with, process, and produce creativity differently, which makes creating a universal definition of creativity very challenging. As Steve Jobs reminds us, even creative people have a hard time seeing the things they think and create as creative! The difficulty in recognizing and defining creativity might stem from the various forms of creative outlets (from the performing arts such as dance and music to the visual arts such as drawing, painting, sculpture, design, photography, and filmmaking). The difficulty may also be due to differences in how people think about the creative thinking processes (Box 1). However, no matter how different our approaches in understanding creativity may be, forming a definition of creativity will help us to understand its various benefits, processes, and expressions.

BOX 1 - THE CREATIVE PROCESS

Steps of the creative process, as defined by the scientist Wallas [1] are as follows:

- 1. Preparation (or Discover and Listen)**—in the first phase, you reflect on your past experiences and any creative work you have made previously in order to prepare to use your creativity in a new way.
- 2. Incubation (or Design and Create)**—after working on the new creative project for a while, sometimes it is a good idea to take a step back and not work on the project for a little bit. Wallas and others have found that many ideas arise after a period of time away from the problem. This phase may be called the Archimedes or Newton phase, where ideas come to you in unexpected places, such as in the bath or under a tree.
- 3. Illumination (or Develop and Implement)**—coming back to the idea, you may find that the problem or creative project “clicks” and the pieces of the idea come together. This is also the time to keep working on the idea or try different variations.
- 4. Verification (or Deploy and Deliver)**—finally, check and see if the idea is new and/or “good.” This may be the stage where a writer looks at the page he has written and crumples up the paper before starting in a new direction.

CREATIVITY CAN SHOW UP UNEXPECTEDLY

Have you ever had an AHA! Moment—one where an idea or solution came to you seemingly out of nowhere? This feeling, defined as insight and sometimes called an epiphany, is one form of creativity. Epiphanies also happen as what we call a “eureka feeling.” The “eureka feeling” actually refers to an ancient Greek scientist named Archimedes, who was tasked with figuring out how to determine whether a crown was made of solid gold or gold mixed with other metals, without breaking the crown. He actually discovered the solution while he was taking a bath! Archimedes noticed that the water level of the bath changed as he got in and out of the tub. He realized that he could calculate the volume of an object by submerging it in water (which is especially helpful for objects with irregular shapes such as crowns). With the mass of the crown already established, Archimedes used the bath water method and the mass/volume = density equation to determine whether the gold crown was pure gold or had less dense (less valuable) metals added.

HOW DO CREATIVE PEOPLE THINK?

Creativity does not only make itself known as random ideas and thoughts that seem to come out of nowhere. Other forms of creative thinking include convergent and divergent thinking. In convergent thinking, you combine multiple, sometimes very different, pieces of information and find one solution/thing that links them. The creativity test best known for determining convergent thinking abilities is called the Remote (or far away) Associates (or things that are similar) Test (RAT for short). During the test, you are given three words and asked to think of a word that is related to all three. For example, you would be given the words blue, cake, and cottage. Can you think of a word that links all of them? Was it cheese—as in blue cheese, cheese cake, and cottage cheese?

Divergent thinking, on the other hand, involves generating multiple different ideas or solutions from a single starting point. An example of a divergent thinking test is the Torrance Test of Creativity. This test asks you to do a number of tasks with both picture- and word-based problems. Across all of the tasks, you are asked to think of as many solutions as possible within a time limit. In one task, you may be shown a picture (such as that in Figure 1) and asked to think of as many answers to the question “how many uses can you come up with for this object?”

WHAT HAPPENS IN THE BRAIN DURING CREATIVE THINKING?

So now that you know about three different types of creativity, insight, convergent thinking, and divergent thinking, you might think that the brain

FIGURE 1

Divergent thinking test. How many different ways could you use a cardboard box? Retrieved from: https://pixabay.com/p-152428/?no_redirect.

**FIGURE 1****WORKING MEMORY**

A memory system in the brain with a limited capacity that is responsible for the short-term holding, processing, and manipulation of information.

ABSTRACTION

A thought process that is characterized by adaptability and flexibility. Abstraction involves considering things that may not have concrete things, or specific objects. Example of an abstract concept is, “freedom” and “law.”

PLANNING

A set of brain functions necessary for the control of behavior. Planning is the process of thinking about and organizing activities required to achieve a goal.

COGNITIVE FLEXIBILITY

Allows you to either easily switch between thinking about two different concepts or to think about multiple concepts at the same time.

processes must be complicated. Previous research has demonstrated that several different thought processes in the brain, including processes called **working memory**, **abstraction**, **planning**, and **cognitive flexibility**, are all critical to creative thinking. This research has also shown that the ability to develop strategies is a key part of creativity (like thinking of new or unusual ways to use common objects such as unflavored floss to cut cake or cheese when you do not have a knife). Neuroscientists (scientists who study the brain), in their attempt to make a connection between creative thought processes and the parts of the brain that may process them, have defined creativity as requiring the mixing and remixing of **mental representations** to create novel ideas and ways of thinking [2] If you look back to Steve Jobs’ quote, you will see that he describes creativity in a similar way. Combining and recombining mental representations is simply connecting things in the brain in the way that the brain stores information.

In order to understand what combining and recombining mental representations means, think back to your own process while solving the RAT question. How did you search for the answer—cheese? Did you try a few words that did not work at first? What did you do next? Your process of trying some words and then others is an example of mixing and remixing mental representations. Similarly, think back to your process of solving the divergent thinking question. With the cardboard box shown in Figure 1, did you think of ways that you could use a cardboard box? You could make a fort, or store things, or make a sign, or make a giant cardboard robot, or do any number of other things.

CREATIVITY IN THE BRAIN

Recently, the ways we think and the parts of the brain that contribute to creativity have become of interest to cognitive neuroscientists. Since creativity is among one of the most complex of human behaviors, it likely requires the coordination of multiple brain regions and types of thinking. Because creativity is so complex, it seems naive to think that creativity can be localized to a single region in the brain. In fact, only a few neuroscience studies have tried to

MENTAL REPRESENTATIONS

Hypothetical symbols in the brain that represent the external reality. Mental representations can be thought of as mental imagery, or the ability to imagine things in your mind like traveling to a place you have never visited or doing things you have never done like fly like super hero.

investigate the regions of the brain responsible for creativity. For a long time, scientists thought that creativity was processed only in the right hemisphere (side) of the brain. However, studies that looked at the activity in the brain while people were doing creative tasks, or in patients who had brain damage that resulted in difficulty with creativity showed that an area of the brain called the frontal cortex (Box 2; Figure 2) was associated with creativity. This seemed to make sense because the frontal cortex processes the previously mentioned cognitive processes (for example, working memory, abstraction, planning, and *cognitive flexibility*).

New research has demonstrated that the hippocampus (Box 2; Figure 2) is also critical for creativity. In one study, it was shown that participants who had damage to their hippocampus had lower scores of divergent thinking as measured by the Torrance Test of Creativity [2]. In a second study, it was shown, using the RAT, that convergent thinking was also impaired in patients with

BOX 2 - THE HUMAN BRAIN DOES NOT HAVE ONE CREATIVE CENTER

Frontal cortex—the frontal cortex has long been thought of as the hub or center of creativity, as it seems to be responsible for many of the functions that contribute to creative thinking (such as working (or short-term) memory).

Hippocampus—the hippocampus is best known for memory of things that you can declare, such as facts and experiences. The processes that the hippocampus performs to process these memories involve storing and retrieving the pieces of these memories from where they are stored in the cortex. In the creative process, similar to remembering experiences by pulling together different parts of the experience, the hippocampus may be used in imagination to pull together ideas in ways that you have not thought of in the past.

Basal ganglia—the basal ganglia is a structure deep within the brain. The basal ganglia process the memory of skills and how to do things—often things that we do not have to think about directly, such as riding a bike. With time and practice doing creative tasks, you get better at them.

White matter—white matter makes up the connections between various brain structures. The better connected the areas of the brain are, the better and faster the brain can process information. In the creative process, having a well-connected brain may allow you to bring together more ideas, more quickly.

FIGURE 2

Brain areas involved in creativity. A number of different parts of the brain are important for creative thinking, including the frontal cortex, hippocampus, and basal ganglia. Retrieved from: <https://upload.wikimedia.org/wikipedia/commons/2/2e/Gray739-emphasizing-hippocampus.png>.

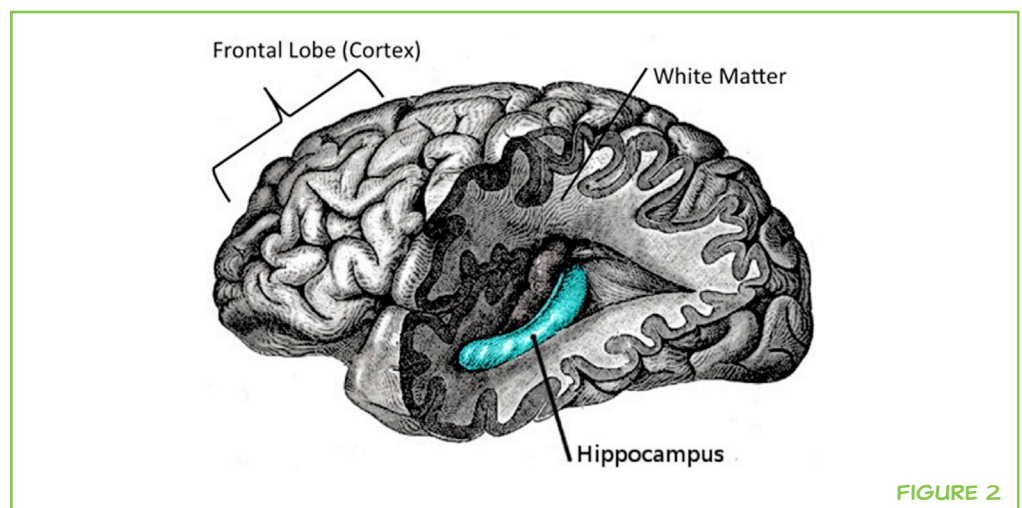


FIGURE 2

hippocampal damage (described above) [3]. Earlier, we mentioned that neuroscientists can define creativity as the mixing and remixing of mental representations. The hippocampus does just this in the mental process that it is best known for, memory. Think back to one of your favorite memories. Maybe it is your last birthday celebration. The hippocampus combines your feelings (joy and happiness to be celebrating with your friends), the scene where it took place (the science museum in your hometown), the actions (blowing out the candles, opening presents), and all of your experiences (seeing all of your friends, smelling the candles burn, hearing Happy Birthday sung) into the memory of your last birthday.

HOW DO SCIENTISTS LOOK AT CREATIVITY IN THE BRAIN?

Previously, we discussed studies that investigated what happens when damage occurs to a particular part of the brain and how that affects the brain's abilities. Those studies allow researchers to look at the necessity of a particular brain area for a certain ability. In other words, if a part of the brain is damaged or missing, can a person still do certain activities? Another method of investigating the brain uses something called functional mapping, which involves the use of technologies to measure activity in the brain. Two functional mapping technologies are called functional magnetic resonance imaging (fMRI), which uses magnetic fields to observe movement of blood bringing fuel materials to parts of the brain that have been active, and electroencephalography (EEG), which measures the electrical activity of the brain.

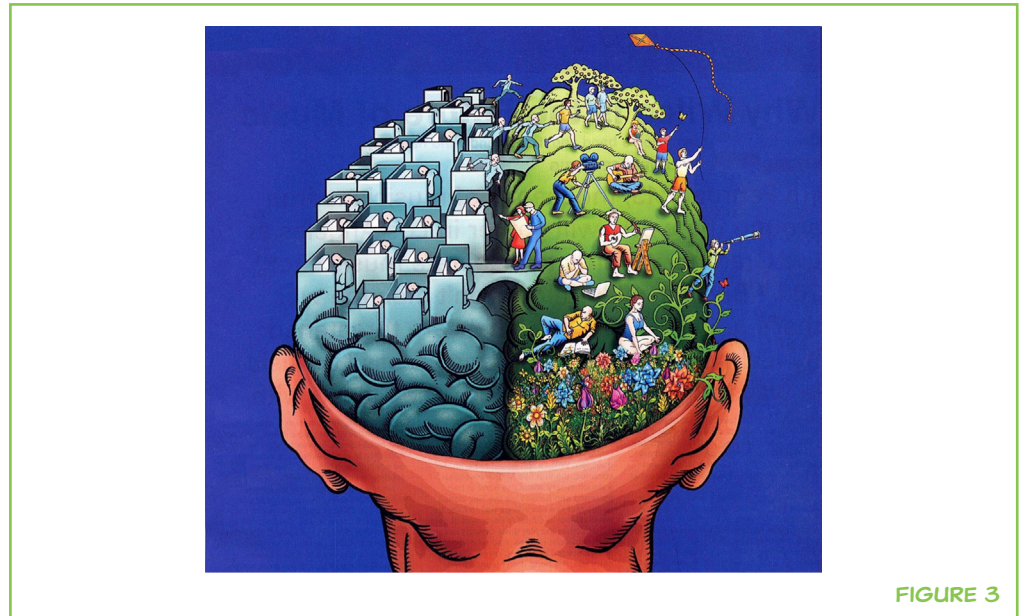
In one study, scientists looked at both fMRI and EEG images taken of participants while they worked on different tasks that involved coming up with creative ideas [4]. The EEG study showed that when they were coming up with creative ideas, study participants had synchronized (firing together) brain activity in the frontal cortex and the parietal lobes. In the fMRI study, more creative responses were related to increased activation (or usage) of the frontal cortex in the left hemisphere. Combining the results from the patient studies and functional imaging studies, we see that there are a lot of parts of the brain involved with creative thinking.

BRAIN MYTHS OF CREATIVITY #1: LEFT BRAIN AND RIGHT BRAIN?

Have you ever been asked if you are left brained or right brained (Figure 3)? This question refers to the idea that each hemisphere of the brain is specialized for different abilities. In general, the left hemisphere has been thought to specialize in understanding words, processing mathematical information, and thinking analytically (the “rational” brain). The right hemisphere, on the

FIGURE 3

The left–right brain myth. People used to believe that the two sides of the brain were specialized for different activities: the logical left and creative right hemispheres. Retrieved from: https://upload.wikimedia.org/wikipedia/commons/a/aa/Right_brain.jpg.

**FIGURE 3**

other hand, was thought to specialize in processing non-verbal information, spatial information, music, emotions, and creativity. As we see in creativity and other complex functions, a number of specialized structures in the brain work together to accomplish something. Localization of certain abilities to one side of the brain or the other was first found in certain individuals who had the main communication between their hemispheres, the **corpus callosum**, cut so that each hemisphere was essentially working independently. In most people, however, the two sides of the brain are able to communicate, so while brain structures may have some specialization, most complex brain functions require many parts of the brain working together.

CORPUS CALLOSUM

A bundle of nerve cells that connect the two hemispheres of the brain.

BRAIN MYTHS OF CREATIVITY #2: CREATIVITY AND INTELLIGENCE DO NOT GO TOGETHER

Similar to the myth that you can only be either left brained or right brained, some think that you can only be intelligent *or* creative. Intelligence is usually defined as the ability to obtain and use knowledge. While intelligence and creativity are somewhat related, they are not the same thing and people can be *both* creative and intelligent, or one or the other [5]. Important factors that make people highly creative probably have something to do with personality—things such as openness to new experiences.

BRAIN MYTHS OF CREATIVITY #3: MENTAL ILLNESS MAKES PEOPLE CREATIVE

Some people have suggested that there is a link between creativity and mental illness. This link could be best described as the “crazy creative hypothesis” or

BIPOLAR DISORDER

A mental disorder that involves periods of depression followed by periods of elevated mood.

SCHIZOPHRENIA

A mental disorder that has a number of different symptoms, some involving abnormal social behavior and problems understanding what is real.

DEPRESSION

A mood disorder that involves low mood that affects a person's behavior, thoughts, and feelings.

the “mad genius hypothesis.” While it may be easy to think of highly creative historical figures who may have been suffering from mental illness, such as the artist Vincent Van Gogh (1853–1890, Dutch painter of *The Starry Night*), poet Sylvia Plath (1932–1963, American Pulitzer Prize winning poet, author of *The Collected Poems*, *The Bell Jar*, and *Ariel*), writer Leo Tolstoy (1828–1910, Russian author, regarded as one of the greatest authors of all-time, known for *War and Peace* and *Anna Karenina*), or others, they represent a small percent of individuals with mental illness and a small percent of people who are creative. Mental illnesses such as **bipolar disorder**, **schizophrenia**, **depression**, and alcoholism have been studied for their potential link to creativity. The findings suggest that highly creative people are not necessarily mentally ill, but may often think in ways similar to individuals with mental illness. In fact, Nancy Andreasen, a leading scholar on the neuroscience of creativity, who has worked with some of the most intelligent and creative people in modern science and the arts, has suggested that many highly creative individuals who were diagnosed with mental illness were not creative *because of* the mental illness but were creative *despite* the mental illness working against them [6].

THE FUTURE OF YOUR BRAIN AND CREATIVITY

While creativity may be a fundamental human ability and pursuit, the study of the source of creativity in the brain has only just begun, so we still have a lot to learn. While scientists continue to learn more about creativity, one thing we already know is that being creative has a number of benefits (Box 3). So even if we do not know exactly which mental processes or parts of the brain are involved with creativity, we can still suggest that you and your friends should go out and be creative, because it will help you and your brain.

BOX 3 - BEING CREATIVE HAS A NUMBER OF BENEFITS

1. **Helps relieve stress:** by becoming involved in a creative practice, you can enter a mental state called “flow” or “the zone” which can help reduce stress levels and leave you feeling calm. You may have experienced a flow state if you have ever lost track of time while doing something you enjoy.
2. **Energizes you:** by pursuing something that you enjoy, being creative can help give you energy by focusing your attention on something that you like rather than dwelling on the worries or bothers of the day.
3. **Helps your emotions:** a number of recent therapies, including music therapy, dance therapy, and art therapy, are being used to help patients with different emotional disorders, including depression and post-traumatic stress disorder. By being creative, you can work through your own emotions and feelings.
4. **Increases your empathy and tolerance:** viewing art has been shown to increase people's feeling of empathy and tolerance toward other people who are different from themselves. By being creative and pursuing creative activities, you can learn more about other people and cultures.
5. **Increases brain plasticity:** your brain makes connections and changes throughout your lifetime. Creating art can stimulate communication between different parts of the brain and having a well-connected brain is thought to be more important for things such as intelligence than the sheer size of various brain structures.

So now that you have all this information about creativity—go out and exercise and showcase your own creativity! Many of us think that we are not creative because we might not be good at drawing or do not have great musical abilities, but everyone possesses some degree of creativity within them. The thing that separates the truly creative people is how they chose to showcase their creativity. Some might illustrate their creativity in art forms such as writing, music, dance, and drawing, others might think about and question the natural world in new ways, but all creativity stems from a specific way of thinking. Push your brain to draw connections between seemingly different ideas, as creativity is just thinking outside the box—anyone can do that. Being creative in your thinking will help you lead a more interesting, healthier, and happier life.

REFERENCES

1. Wallas, G. 1926. *The Art of Thought*. Turnbridge Wells: Solis Press.
2. Duff, M. C., Kurczek, J., Rubin, R., Cohen, N. J., and Tranel, D. 2013. Hippocampal amnesia disrupts creative thinking. *Hippocampus* 23(12):1143–9. doi:10.1002/hipo.22208
3. Warren, D. E., Kurczek, J., and Duff, M. C. 2016. What relates newspaper, definite, and clothing? An article describing deficits in convergent problem solving and creativity following hippocampal damage. *Hippocampus* 26(7):835–40. doi:10.1002/hipo.22591
4. Fink, A., Grabner, R. H., Benedek, M., Reishofer, G., Hauswirth, V., Fally, M., et al. 2009. The creative brain: investigation of brain activity during creative problem solving by means of EEG and fMRI. *Hum. Brain Mapp.* 30(3):734–48. doi:10.1002/hbm.20538
5. Welter, M. M., Jaarsveld, S., van Leeuwen, C., and Lachmann, T. 2016. Intelligence and creativity: over the threshold together? *Creat. Res. J.* 28(2):212–8. doi:10.1080/10400419.2016.1162564
6. Andreasen, N. 2006. *The Creative Brain: The Science of Genius*. New York, NY: Plume.

SUBMITTED: 20 August 2016; **ACCEPTED:** 24 April 2017;

PUBLISHED ONLINE: 12 May 2017.

EDITED BY: Silvia A. Bunge, University of California, Berkeley, USA

CITATION: Cavdarbasha D and Kurczek J (2017) Connecting the Dots: Your Brain and Creativity. *Front. Young Minds* 5:19. doi:10.3389/frm.2017.00019

CONFLICT OF INTEREST STATEMENT: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

COPYRIGHT © 2017 Cavdarbasha and Kurczek. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution

or reproduction in other forums is permitted, provided the original author(s) or licensor are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.



REVIEWED BY

AMALIA, 14 YEARS OLD

I am Amalia and my hobbies include, dancing, eating, sleeping, and outdoorsy stuff.



AUTHORS

DITA CAVDARBASHA

English Major/Creative Writing Concentration and Psychology Minor at Haverford College. I feel as though poetry is one of the most obvious displays of humanness and my neuroscience and psychology classes have made me look to the root of this humanness: the brain. Brain-behavior relationships, brain processes, and the brain in general fascinate me, as they are the things that make us think, feel, and create. As I go further in my college education, I hope to connect poetry and psychology in way that will help me better understand myself and the world around me.



JAKE KURCZEK

I am a brain scientist and I explore how language, memory, and social interaction work together. I use measurements of the brain and body to examine the mechanisms in the brain that control how our memories affect our abilities to communicate and interact. My goal is to help people who have memory issues to have better lives with their friends and families and to find ways to structure language to improve our memory retention. I also look to involve the public in both my research and teaching through science popularization.

*jake.kurczek@loras.edu