Creativity is usually perceived as an abstract concept, but this work tries to indemnify creativity as a physical process. This work elaborates creativity and connection between creativity and processes in the brain. In introduction basics concept of creativity is introduced, as well as importance of creativity for human civilization. Creativity is then more elaborated with definitions and it’s history. Subsequently, basic physiology of the human brain is described. Link between creativity and brain physiology and processes in human brain are explained in the last section. In conclusion main ideas and facts are pointed out.

Key words: creativity; brain; physiology; psychology; neuroscience

1. Introduction

Psychologists usually define creativity as the capacity to produce ideas that are both original and adaptive. In other words, the ideas must be both new and workable or functional. Thus, creativity enables a person to adjust to novel circumstances and to solve problems that unexpectedly arise. Obviously, such a capacity is often very valuable in everyday life. Yet creativity can also result in major contributions to human civilization [1]. Despite great progress in the neuroscience the higher cognitive functions, such as language, thinking, reasoning, planning, problem solving, understanding of visual scenes, are still poorly understood. Creativity seems to be one of the most mysterious aspects of the human mind and any attempt to elucidate brain processes involved in it, has been surely speculative [2]. In this work I will introduce basics of creativity, brain and link between them.

2. Creativity

There are many definitions of creativity, Peter Meusburger in his work reckons that over a hundred different analyses can be found in the literature [3]. Dr. E. Paul Torrance described creativity as "a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies: testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results[4]. Michael Mumford, professor at University of Oklahoma, wrote that over the course of the last decade, scientists seem to have reached a general agreement that creativity involves the production of novel, useful products [5]. In history, creativity was not known concept
until the Renaissance. The ancient Greeks had no terms for creativity or creation and Plato did not believe in art as a form of creation [6].

The development of the modern concept of creativity begins in the Renaissance, when creation began to be perceived as having originated from the abilities of the individual, and not God. This could be attributed to the leading intellectual movement of the time, aptly named humanism, which developed an intensely human-centric outlook on the world, valuing the intellect and achievement of the individual [7].

3. Brain and creativity

The human brain is the central organ of the human nervous system, and with the spinal cord makes up the central nervous system. It controls most of the activities of the body, processing, integrating, and coordinating the information it receives from the sense organs, and making decisions as to the instructions sent to the rest of the body. The largest part of the human brain is the cerebrum, which is divided into two hemispheres. Underneath lies the brainstem, and behind that sits the cerebellum [8]. The cortex is mapped into about fifty different functional areas known as Brodmann’s areas. These areas are distinctly different when seen under a microscope [9].

Neuroscience, scientific study of nervous system, looks at creativity as operation of the brain during creative behaviour. In the article “Creative Innovation: Possible Brain Mechanisms.” [10], authors write that creative innovation might require coactivation and communication between regions of the brain that ordinarily are not strongly connected and that highly creative people tend to differ from others in three ways:

• they have a high level of specialized knowledge,
• they are capable of divergent thinking mediated by the frontal lobe.
• and they are able to modulate neurotransmitters such as norepinephrine in their frontal lobe.

This suggests that the frontal lobe appears to be the part of the cortex that is most important for creativity. Interesting case is brain autopsy of Albert Einstein, who has reputation as one of the foremost geniuses of the 20th century, and certainly was very creative. Scientific studies have suggested that his brain regions involved in speech and language are smaller, while regions involved with numerical and spatial processing are larger. A study, "The cerebral cortex of Albert Einstein: a description and preliminary analysis of unpublished photographs” states that although the overall size and asymmetrical shape of Einstein's brain were normal, the prefrontal, somatosensory, primary motor, parietal, temporal and occipital cortices were extraordinary. Also, there was a fourth ridge (apart from the three normal people have) in Einstein's mid-frontal lobe involved in making plans and working memory [11].

Creativity has been relating to intelligence since the late 1900 and since then many influential studies have been published.

There are multiple theories accounting for their relationship, with the 3 main theories as follows:

• Threshold Theory – Intelligence is a necessary, but not sufficient condition for creativity. There is a moderate positive relationship between creativity and intelligence until IQ ~120 [12].
• Certification Theory – Creativity is not intrinsically related to intelligence. Instead, individuals are required to meet the requisite level intelligence in order to gain a certain level of education/work, which then in turn offers the opportunity to be creative. Displays of creativity are moderated by intelligence.

• Interference Theory – Extremely high intelligence might interfere with creative ability.

Sternberg and O’Hara proposed a framework of 5 possible relationships between creativity and intelligence:

1. Creativity is a subset of intelligence
2. Intelligence is a subset of creativity
3. Creativity and intelligence are overlapping constructs
4. Creativity and intelligence are part of the same construct (coincident sets)
5. Creativity and intelligence are distinct constructs (disjoint sets)

If creativity is considered from the neural base, a first most classical approach refers to the different functions of the two cerebral hemispheres. Left side performs tasks that have to do with logic, such as in science and mathematics. On the other hand, the right hemisphere performs tasks that have do with creativity and the arts. The separation of the hemispheric competences often results in a notion of the creativity in which right brain function are associated with creative, emotional and instinctual processes.

However, the last findings related to the neuroscience of creativity suggest that right to left brain distinction does not offer the full picture of how creativity is implemented in the human brain. It is stated that creativity does not involve a single brain region or a single side of the brain. In contrary, depending on the type of creative process and the stage of the creativity, different brain regions are recruited to handle the task.

The creative process can be divided into four stages:

1. The preparation stage that consists of problem defining and gathering of all information’s that are needed, as well as setting the criteria for verifying their acceptability.

2. The incubations stage infers the distancing from the problem and contemplation over the gathered information.

3. The ideas arise from the mind to provide the basis of a creative response in the illumination stage. Unlike the previous stages, illumination is often very brief and involves a tremendous rush of insight.

4. In the finale stage, known as verification, the activities are carried out to see whether or not results of illumination stage satisfy need and criteria defined in the preparation stage.
4. Conclusion

Creativity plays important role in the progress of human civilization, and has been subject of many researches. Some of these researches concentrated on brain processes that are involved in creative thinking. Although creative process is associated with right side of the brain, studies show that multiple regions of brain are involved in creative process which consists on multiple stages. Also, linking different parts of brain showed important role in creativity. To develop creative and inventive thinking it is important that during infancy multiplicity of activities are encouraged, such as free and social play, analogical thinning and focused attention.

REFERENCES