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Emotional Neuroscience and Learning. An Overview

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Abstract. In recent years, there has been a growing interest in examining the effect of emotion on learning. The relationship between neuroscience and education is direct, and emotional neuroscience has a significant impact on the learning process. This study's primary objective is to examine the connection between emotional neuroscience and the learning process. Therefore, the effects of emotion on cognitive function, memory, and learning processes were reviewed. A search was conducted using electronic databases (PubMed and Scopus). To emphasize the most recent literature, articles published within the last fifteen years were sought out. Based on the review of studies, it was determined that emotional neuroscience and learning have a strong correlation. Notably, both positive and negative emotions can have an impact on a person's cognitive functions, with the greatest impact on attention, memory, and learning.

Keywords. Emotional Neuroscience, Learning, Memory, Educational Setting

1. Introduction

In recent years, there has been an enhanced interest in studying and evaluating the influence of emotion on memory and learning. Emotions are directly related to a person's personal and social aspects of life. Moreover, emotions generate images, memories, and memories that are directly and indirectly related to the environment and social activities of individuals (Harm et al., 2018). Consequently, the brain and neurophysiological functions of the human body are increasingly studied, and specific brain activities related to memory and learning have been mapped. Particularly, learning, which helps individuals develop, develop improved ways of thinking, acquire knowledge, and acquire new abilities and skills, can be more effective when the individual understands emotions and their effects on the learning process. The present study focuses on emotional neuroscience and its relationship to learning, presenting key findings and conclusions derived from a review of recent literature (Antonopoulou et al., 2022; Antonopoulou et al., 2021; Giannoulis et al., 2022; Gkintoni et al., 2022a; 2022b; Gkintoni et al., 2021). In particular, the connection between neuroscience and education will be studied. Then, emotional neuroscience will be highlighted, and the influence of emotions on the learning process will be examined, where the most significant findings of this review will be presented.
2. Literature Review

Neuroscience and Education

In recent decades, the relationship between neuroscience and education has been of particular interest to scientists and researchers. This relationship has always been the subject of research and study. However, it has been studied more in recent years, as it is directly related to and affects numerous aspects of human life. Today, Neuroeducation is defined as learning strategies that are directly linked to particular brain functions (Watson & Platt, 2008). Neuropedagogy refers to the integration of neuroscientific findings into school practice and other fields related to educational leadership and management (Antonopoulou et al., 2021a; 2021b; 2021c; 2020, 2019). Neuropedagogy involves, among other things, the application of knowledge regarding brain functions to the teaching and learning of mathematics (Gkintoni et al., 2021). Educational Neuroscience investigates the formation of mental representations from a neurophysiological standpoint (Halkiopoulos et al., 2022). Therefore, it is clear that there is a strong connection between neuroscience and education. During the investigation of neurosciences, key questions regarding the learning process and its relationship to specific brain functions have been answered. With the development of contemporary neuroimaging techniques, it is now possible to evaluate brain activity during every human action. Using specialized gamification techniques, it is also possible to capture the brain's cognitive functions and issues related to learning and education in general based on findings from the field of neuropsychology gleaned from the use of various tests (Antonopoulou et al., 2022). The results of these studies can provide answers to fundamental questions regarding brain function, such as how the organization of the human brain changes as a person develops new skills and abilities (Halkiopoulos et al., 2021). In recent years, neuroscience has also contributed to the field of Genetics, demonstrating that genes determine an individual's development through brain-based processes and their influence on learning. Therefore, genes are strongly associated with both learning and the various learning difficulties a person may exhibit (Thomas et al., 2019).

3. Methodology

To perform the present study, a literature evaluation was conducted using electronic databases such as Pubmed and Scopus. Neuroscience, emotional neuroscience, learning, education, memory, and emotional profile were some of the terms used in the search. In addition, the search was restricted to articles published within the past fifteen years.

4. Results

Genes and the individual's environment are the two most influential factors on the individual's development and the learning process, according to the literature review. The neurosciences now provide valuable insights into a variety of educational aspects. Language, reading, speech development, and mathematical reasoning are essential areas of study in neuroscience. Likewise, the individual's social development, which is directly related to the emotional brain and the effect of emotions on the learning process, is also essential. Emotions are essential elements in a person's life. They are connected to stimuli from the external environment to a person's lifestyle or survival conditions, and constitute the response to any environmental change (Gkintoni et al., 2017).

Specifically, when a person works in a pleasant and stimulating educational-work environment, he is less likely to experience occupational burnout and does not lose his well-being, which contributes to a higher quality of life (Gkintoni et al., 2021; Gkintoni et al., 2019a; 2019b). In addition to affecting the workforce and the workplace, burnout impacts educational
environments by reducing performance, delaying the completion of educational tasks, and diminishing the quality of services provided, thereby disrupting the school climate. Specifically, the effects are classified as a) effects on the educational organization, the individual, and interpersonal relationships; and b) effects on the individual (Halkiopoulos et al., 2020). Several researchers associate teacher burnout with a negative attitude toward their work in the school setting. Individual attitudes are voluntary withdrawal, absenteeism, decreased satisfaction, decreased performance and engagement, lack of concentration during the educational process, high health insurance premiums, and lack of creativity (Tzanos et al., 2019). Particularly, research conducted on teachers revealed the following symptoms: a decline in teaching quality, a decrease in enthusiasm and indifference, withdrawal and intolerance, and an overall low quality of life index (Hogan & McKnight, 2007).

The hippocampus is primarily responsible for regulating human emotions, along with the hypothalamus, the anterior nucleus of the thalamus, and the afferent gyrus, according to neuroscientific evidence. In contrast, connections between the amygdala and certain regions of the brain that regulate the sense of smell have been discovered (Gkintoni & Dimakos, 2022b). Emotion has a significant impact on a person's memory and learning because it is involved in information processing-related brain functions. Also discovered are the effects of emotion on attention, concentration, learning, perception, reasoning, problem-solving, and decision-making (Halkiopoulos et al., 2022).

**Emotional Neuroscience**

Emotional neuroscience is a distinct field that explores the connection between brain function and human emotions. Emotional state refers to a person's reaction to any external stimulus and everything that occurs around them, which can last for several seconds, hours, or even days. Man's emotional state manifests itself through mood swings. The expressive style, on the other hand, determines how a person will respond to stimuli from the external environment and is the source of human emotions. Specifically, each individual is born with a distinct expressive style, which is determined by six individual parameters: vision, body perception, flexibility, adaptability, attention, and social intuition (Halkiopoulos et al., 2022). Visual refers to the duration of maintaining a positive or negative emotion and is influenced by the ventral striatum, a brain region associated with the reward system of the human brain. Then, the perception of the body involves awareness of the person's emotions and thoughts.

Flexibility determines the time and speed required to recover from an issue, impediment, or challenge encountered. The communications between the prefrontal cortex and the amygdala of the human brain have a direct effect on adaptability. Adaptability, on the other hand, refers to an individual's ability and skill to regulate and adjust the diverse emotional responses to external stimuli or events. The hippocampus's activities influence adaptability.

The prefrontal cortex of the human brain has a direct influence on the dynamics of an individual's dedication to a particular piece of information or activity. Social intuition refers to a person's ability to receive messages and stimuli from their environment. The interactions between the amygdala and fusiform region of the human brain influence social intuition (Gkintoni et al., 2021).

The determinants of an individual's expressive style, namely perspective, adaptability, social intuition, and flexibility, play a crucial role in managing and controlling the individual's emotional world and emotional disturbances and conflicts. Studies have demonstrated that genes can influence an individual's emotional profile by 20% to 60%. Environment and experiences will account for the remaining percentage (Watson & Platt, 2008).
In addition, the term neuroplasticity of the brain is significant, which refers to the brain's skill and capacity to acquire new habits and shape its activity based on the individual's diverse thoughts, expectations, ideas, desires, and experiences. Recent research indicates that this cognitive ability can emerge in the elderly (Korte, 2013).

This, of course, implies that every individual is capable of re-designing and modifying their brain's neurons based on factors that determine their emotional style. Brain neuroplasticity can assist in enhancing brain function and aiding in the resolution of problems or correction of certain disadvantages and disorders associated with brain activity. This can occur at any age and requires patience and persistence (Gkintoni et al., 2022).

**Emotion and Learning**

Human emotions can influence and reshape the memory system directly affected by the hippocampus, according to studies in psychology and neuroscience. Consequently, the interaction of the aforementioned two systems allows emotion to exert direct or indirect effects on memory and learning (Barron et al., 2015). Every emotional process has an immediate or long-term effect on a person's cognitive system; therefore, there is no emotional response that does not influence cognitive function. In addition, the hippocampus is responsible for the development and comprehension of declarative memory, that is, the human's long-term memory, which involves the storage and categorization of information. Examples of distinct categories include the mathematical formulas and vocabularies that a person acquires, as well as specific life events. At the same time, the hippocampus serves as the hub of the human brain's communication network. This is based on the discovery that the hippocampus is responsible for the continuous exchange of information, and on the assumption that it is the control center of all these continuously exchanged data between the various brain regions (Berridge & Kringelbach, 2008). The hippocampus determines and influences the short-term and long-term learning memories of an individual. In addition, it has been demonstrated that the hippocampus frequently collaborates with the amygdala of the brain to encode a person's memory, thereby producing certain emotional information.

In addition, the function of the amygdala is involved and affects the emotional process of the brain, strengthening the person's memory and creating new, long-lasting memories, according to research on fear-related learning. Therefore, this demonstrates that a person's emotions have direct and indirect effects on the formation of his memory. In addition, magnetic resonance imaging of the human brain has demonstrated that the hippocampus is responsible for memory encoding processes, which sometimes refer to the emotional and sometimes to the neutral content of the provided information. Also, during negative emotions, the hippocampus and amygdala of the brain collaborate to correctly encode the corresponding memory (Gkintoni et al., 2022).

Regarding the various interactions between the amygdala and the hippocampus of the brain, it appears that the amygdala may be involved in processes in which the individual's emotional nature is stimulated, stored, and encoded by the corresponding memories resulting from the emotion. This indicates that the amygdala may be activated and function to encode specific emotionally stimulating data in response to an individual's external stimuli. These data may pertain to positive and negative emotional states (Gkintoni et al., 2021b).

Specifically, each stimulus of a person's external environment can cause a new emotional response or a different emotional experience, which increases the secretion and release of certain hormones, the so-called stress hormones. Hormone secretion activates the
brain's amygdala, which, in conjunction with the hippocampus, encodes specific information and consolidates a new memory.

The interaction between the prefrontal cortex and the hippocampus is of equal importance. The prefrontal cortex of the brain is located in the anterior basal region of the frontal lobe. It is directly related to the individual's higher cognitive functions, such as predicting potential future outcomes. In addition, the prefrontal cortex is believed to serve as a control center for selective attention and play a crucial role in information processing and storage. In addition, the prefrontal cortex is a region of the human brain that is directly associated with cognitive function, problem-solving, reasoning processing, and emotional responses (Novick et al., 2019).

Consequently, it is evident that the prefrontal cortex of the brain interacts with the hippocampus. In fact, it has been demonstrated that the cooperative operation of these two brain regions is essential for optimal long-term memory formation. This occurs when the activity of the prefrontal cortex of the brain leads to emotional interference and interaction with the cognitive functions associated with the activity of the hippocampus in the human brain. Thus, we can see how emotion can either strengthen or weaken memory and learning. Initially, learning is an active process that results from collaboration and the integration of old and new data. Then, learning is an infrequently emotionless human activity.

A child learning to walk, for instance, initially experiences happiness, excitement, and other positive emotions that result in the formation of happy memories. However, if he falls or is hit, he will experience negative emotions such as fear, sadness, and frustration, which will impact his memories and the overall process of learning to walk. Therefore, there cannot be a learning process that is independent of or unrelated to a person's emotional response. In fact, for many years, learning was analyzed primarily in terms of the individual's cognitive functions, while interactions with the individual's emotional activity and response to any possible environmental stimulus were ignored.

In recent years, however, learning and emotion have come to be viewed as interdependent variables, and the effects of emotion on the learning process have been extensively studied. Through the study of neuroscience pertaining to the individual's learning process and education, several specialized programs have been developed and tested in experimental clinical trials with autism, developmental motor disorders, and other groups with learning difficulties (Rosenberg et al., 2020).

According to findings from related studies, there is a strong correlation between emotion and the learning process of sensitive groups. Therefore, the individual's emotions and mood have a substantial effect on the process of encoding and storing the provided information. In other words, they influence the learning process. A person whose mood and emotions fluctuate frequently may also experience fluctuations in cognitive functioning. The stimulation of a person's mood, with either a positive or negative emotional outcome, can influence the learning process, strengthening or weakening it depending on the circumstance. These emotions influence the individual's disposition, creating new memories and encoding and storing either positive or negative information. Then, the individual's pleasant or unpleasant memories lead to the formation and expression of new positive or negative emotions, respectively. Therefore, this process functions as a vicious circle and demonstrates that human emotion and learning are interrelated but interdependent.

In addition, there is a theory known as the "mood-congruence-hypothesis," which holds that certain cognitive relationships in the human brain are fundamentally linked to the organization of the brain and various brain functions. This theory asserts that a person's mood
can have both positive and negative effects on their relationships. A person's activity that results in a positive outcome, for instance, generates positive emotions, while his improved mood strengthens and facilitates the learning process. In contrast, negative feedback from a failed attempt is more likely to hinder and impede the individual's learning process. There is also a theory known as mood as information, which refers to the belief that a person's positive mood will assist him in approaching a problem or situation with optimism. In contrast, a negative mood is predicted to have negative effects on information encoding. Therefore, a positive disposition and an optimistic outlook indicate a safe and tranquil environment that will assist the individual in accepting and mastering information (Celeghin et al., 2017).

5. Discussion and Conclusion

Individuals' education and learning are directly related to the various sections of neuroscience, according to the findings of the present study. Years of research in the neurosciences have answered many fundamental questions concerning learning and the relationship of learning to certain essential functions of the human brain.

With the advanced technological means and the progress of the sciences, the activity of certain areas of the brain, linked to the processing and encoding of information, has been visualized. For instance, the hippocampus and amygdala have been identified as essential brain regions for the performance of cognitive functions. In the past, it was believed that these two brain regions functioned independently; however, recent research has demonstrated a strong and interconnected relationship between the two regions.

In fact, the hippocampus, which has long been associated with a person's cognitive functions and activities, is profoundly affected by the individual's emotional state. In contrast, the amygdala of the brain, which for many years was believed to be determined by an individual's emotion and mood, now appears to be directly associated with a variety of cognitive functions. Therefore, cooperation between these two fields can result in a better understanding of emotions and more efficient information processing and encoding.

In addition, it was discovered that a person whose emotions and moods fluctuate frequently can exhibit significant fluctuations in cognitive functioning. The stimulation of a person's mood, regardless of whether it is a positive or negative emotional state, can affect the learning process by enhancing or hindering it.

It has been demonstrated that emotions affect a person's mood to the extent that they create new memories after encoding and storing positive or negative data. Then, the individual's pleasant or negative memories develop and release new positive or negative emotions, respectively. Therefore, this process functions as a vicious circle and demonstrates that human emotion and learning are interrelated but interdependent.

Therefore, the distinction between a person's cognitive and emotional brains is ambiguous and requires additional study. However, it has been found that there is a strong interaction between emotion and learning, while this relationship is primarily based on genetic factors but also on elements of the external environment. The emotional characteristics and states of an individual can have both positive and negative effects on information processing and storage, attention, concentration, memory, and the learning process. For instance, a person with a positive disposition and positive emotions can encode and process information more effectively. Therefore, emotion significantly influences the learning process. To contribute to the overall learning process, the individual must recognize the positive or negative emotion, comprehend it, process it, and encode it accordingly. Both emotional neuroscience and brain neuroplasticity will continue to be researched in the future. Simultaneously, it is anticipated that
they will soon announce additional significant evidence for the effect of emotion on learning and the development of healthy cognitive networks in the human brain, which will be achieved by enhancing positive emotions.

References


