

ECPS5003: The Brain, Biology, and Cognition

The human brain consists of many questions which many researchers are longed to answer. With its marvel of complexities, the brain continues to intrigue scientists with its enigmatic workings. Regardless of the fact that many researchers have studied this vital organ within the central nervous system, there remain matters that are still left to be understood. Besides the unanswered mystery of one's brain, scientists have already elucidated the basic, yet fundamental purpose and functions of the brain to the public. The complexity of the brain introduces its functions and versatility ranging from the communication within the nervous system from or to the brain, orchestrating every thought, movement, or sensation one can have. The human brain shows its diversity when it comes to functioning as a person. Therefore, it is also to be mentioned that the organ contains various nervous tissues that mandate one's emotions, languages, memory, and many more task-evoked responses that one can do. Moreover, the brain is composed of neuron cells that process information and it consists of more than 100 billion neurons (Maldonado & Alsayouri, 2023). This explains why an individual can do such tasks that may seem trivial but are crucial to human life.

It is essential to take note that the anatomy of the brain plays a unique role in the core objective of this forthcoming essay. In the human brain, there are three parts, for instance, cerebellum, cerebrum, and brainstem. Starting off with the cerebellum, its main function is the adapt an individual's motor coordination (Glickstein & Doron, 2008). The cerebellum connects itself to the brainstem, which is the other main part of the brain, by cerebellar peduncles. According to Ackerman (1992), the brainstem controls one's vital tasks, such as controlling breathing, blood vessels, and heart beating. Lastly, the cerebrum is the biggest and largest section of the brain compared to other sections, hence why it is divided into left and right hemispheres (Maldonado & Alsayouri, 2023). According to the image provided for the essay,

besides the damaged area, there are seven areas that were mentioned. The areas of the anatomy mentioned were the amygdala, mammillary body, septum, fornix, longitudinal fissure, right cingulate cortex, and left cingulate cortex. However, the damaged area that will be the focus of this essay is the left hippocampus.

Before delving deeper into the damaged left hippocampus, it is essential to appreciate the broader context and insight of the overall function of the hippocampus in general. This particular brain structure, the hippocampus, is known to have a key role in terms of learning and memory. It extends from the temporal part of the cerebral cortex, and it is densely packed with neurons, which makes it curl into an S-shaped structure, as shown in the image for the essay (Anand & Dhikav, 2012). Anand and Dhikav also suggest that the hippocampus merely serves its central function for an individual's memory, spatial navigation, and learning. Taking a closer look at the hippocampus from a cognitive point of view, this brain structure is important to the spatial navigation of information (Eichenbaum, 2017). When it comes to spatial navigation, the hippocampus is the core region that predominantly takes place, where it integrates pieces of information from specific locations from various sensory modalities. Therefore, they use it by using the process, involving encoding spatial relationships into a global cognitive map. (Iggena et al, 2023)

In this forthcoming essay, the implications of the damaged left hippocampus will be critically examined from both cognitive and biological points of view. This essay will further elaborate and delve into how the effects of the impaired left hippocampus can alter an individual's ability to learn and how they can engage in multiple cognitive processes. Furthermore, this essay will explore its broader implications for the overall operation of the brain.

Theories Relating to The Damaged Left Hippocampus

Prior to delving deeper into the topic, it is imperative to emphasize that the damaged area is located on the left hippocampus of the left hemisphere. The effect that takes place of the impairments in the left hippocampus or both parts of the hippocampus can lead to major issues. According to Shetty (2014), harm to the hippocampus can manifest in several causes, like as, Alzheimer's disease, head trauma, stroke, and other factors. As stated before, one of the functions that the hippocampus focuses on is memory, hence a study was conducted regarding this subject. According to Cooper et al (2011), this particular part of the brain supports the retrieval of autobiographical memories. Autobiographical memories are known to recall past events from an individual's life, which is what the hippocampus does (Cabeza & Jacques, 2007). As to focus on the consequences of the injured left hippocampus, it should be highlighted that generally the left is mainly concerned with the manipulation of verbal semantic representations, as suggested by Abrahams et al (2003). Therefore, understanding the consequences of injury to the left hippocampus is crucial for comprehending its impact on memory and cognitive processes.

Directing the essay's attention towards both the cognitive and biological effects of the impairment of the left hippocampus, this upcoming paragraph will specifically concentrate on the biological ramifications of the damaged area. The region of the brain, the left hippocampus, affected by the injury can be associated with a few theories. Nevertheless, the concept of neuroplasticity will be the primary emphasis for now. According to Puderbaugh and Emmady (2023), neuroplasticity involves the brain's ability to adapt through functional, as well as structural changes. In essence, the brain has the capability to reorganize itself in response to modifying challenges in behaviour, environment, injury, or disease. According to Berlucchi and Butchel (2008), the term 'plasticity' has been used for over a century to describe the changes that are suspected in neural organization. In addition, it includes various different

forms of compensatory adjustments and learning, which are taken in response to functional losses due to ageing or brain damage. Therefore, this concept is relevant to the damage in the left hippocampus, as the general function of this particular region has been altered. Moreover, since the hippocampus is responsible for memory recall, its impairment, as in the case of the left hippocampus, can hinder this function. Therefore, the theory shows relevance to the damage, according to Liu et al (2017), in which hippocampal synaptic plasticity plays an essential role in terms of hippocampus-dependent explicit formation. This is due to the fact that when the hippocampal plasticity makes an alteration, it can result in many negative stimuli, such as stress. Liu et al (2017) also explained that hippocampal synaptic plasticity widely plays a crucial part in hippocampus-dependent explicit memory formation. The reason is that stress can decline the neuronal dendrite plasticity and branching in the hippocampus, especially when we relate this to the damaged left hippocampus. However, a study conducted by Liu et al (2017) contradicted the concept of the impairment of the left hippocampus. This is due to the fact that the research study concluded that the right hippocampus body and tail underwent slightly greater volumetric decreases than the left hippocampal. Therefore, there is a downside to this theory as it mostly discusses the consequences of the right hippocampus.

Another theory that is significant to the impairment of the left hippocampus is referred to as the Medial Temporal Lobes (MTL) theory. This theory specifically refers to both biological as well as cognitive effects of the impaired area. According to Race et al (2011), the MTL theory plays a vital role in an individual remembering their past memories and imagining the future through the usage of the hippocampus exceptionally. Thus, considering the biological effects, Scoville and Milner (1957) suggested that left damage to the hippocampus can cause severe memory impairments. This heavily impacts the Medial Temporal Lobes as this theory has its own responsibility to encode memories into relational information, as discussed by Olson (2006). Now we shift our concentration towards the cognitive side. Similarly, Race et al

(2011) discussed, that when it comes to envisioning future events, amnesic patients with MTL damage, as well as serious autobiographical memory loss have the tendency to exhibit prominent impairments when they try to visualize their future events to do so. Furthermore, when an individual with a damaged left hippocampus tries to recall memory or envision future events, they tend to struggle. A case study in relation to this is known as the R.B. case, in which the damage to the hippocampal formation has been correlated with impaired memory in patients with amnesia. Furthermore, patient R.B. was reported to suffer profound amnesia and thus came back with the result of damage that is constrained to the hippocampal formation. Therefore, it makes it plenty enough and sufficient to generate anterograde memory impairment. In other words, Victor and Agamanolis (1990) stated that patient R.B. precisely had bilateral damage limited to the CA1 field of the hippocampus, which resulted in him developing severe anterograde amnesia. A study conducted by Zola-Morgan et al. (1986) came back with the result of three cases of amnesic patients, G.D., L.M., and W.H., and found that the three cases strongly correlated with the findings of patient R.B. Therefore, the idea of the hippocampal formation greatly is essential for memory and the R.B. case proves that the hippocampal damage itself can develop amnesia to an individual. According to Rempel-Clower et al. (1996), the impairment of the hippocampal formation seemed to correlate with the seriousness of memory impairment. The results of the research study found that patient G.D. has similar damage to R.B., where the CA1 field of their hippocampus is impaired on both sides of the hemisphere, resulting in them having anterograde amnesia and retrograde amnesia. The case study of patient R.B. underline the impact of hippocampal impairment on memory function. Although the case discussed the bilateral damage, it still signifies that the damage to the left hippocampus can still alter how an individual recalls their memories.

As mentioned earlier, where patients reported having trouble imagining their future events due to their medial temporal lobe damage. Even though the Medial Temporal Lobes

(MTL) theory supports the concept of the impaired left hippocampus, a recent study carried out by Squire et al., (2010) criticized this perspective. In addition, the study reported its result, disproving that amnesic patients with Medial Temporal Lobes (MTL) damage are still able to picture or imagine their future experiences. Likewise, the researchers debated that MTL does not necessarily have to be responsible for imagining the future. Therefore, it critically questioned whether impairments of future thinking are able to result from damage that is specifically to the Medial Temporal Lobes (MLT).

When looking into the cognitive perspective of the hippocampus, they show much evidence that without the left hippocampal functioning, an individual will have difficulty in remembering their memories. The standard consolidation theory (SCT) is widely known as where throughout a period of time, the memory reorganization starts, or in other words, consolidates with the neocortical (extra-hippocampal structure). After it consolidates, the memory can be retrieved or recalled without only going through the process with the hippocampal, in order to protect the hippocampal damage. In other words, an individual's memories become less reliant on the hippocampus for retrieval over time. When studying and gathering evidence of this theory from patients with damage to their hippocampus. These patients not only suffer from severe anterograde amnesia but also have a particular kind of memory loss in which they forget things that happened before their injury, which is essentially known as temporally graded retrograde amnesia (TGRA). (Winocur & Moscovitch, 2011). By delving into this case study of standard consolidation theory (SCT), the evidence supports and demonstrates the critical role of the hippocampus, including the left hippocampus. It is to say that when the left hippocampus is damaged, one can have trouble in memory consolidation and retrieval processes in their hippocampal.

Another theory that is similar to the standard consolidation theory, is referred to as Multiple Trace Theory (MTT). The multiple trace theory has the same elements as the previous

theory mentioned, however, instead of memory retrieval no longer relying on the hippocampus, the hippocampal complex is always involved in the retrieval and storage of episodic memories, regardless of age. (Nadel et al., 2000). Additionally, there is still consistency from one theory to another. According to Nadel et al. (2000), it was believed that between the hippocampal complex and neocortex having long-term interactions can have an impact on the stabilization of the semantic memories within the neocortex. Therefore, it means that the hippocampal complex will always have an influence on both semantic and episodic memories. By having a significant comparison, yet contrast with both theories, it can be simply described that the multiple trace theory proposed that semantic memories have their independence as time goes on, yet, the episodic memories or contextually rich memories will always have their dependence on the hippocampus (Akers & Frankland, 2009). In other means, when putting into the context of an individual with an impaired left hippocampus, the hippocampus is unable to retrieve nor store its memories due to it being damaged and thus not having the necessity to have help on the hippocampus.

The damaged hippocampal, especially the left hippocampus, can lead to many clinical problems. Studies have shown that if one of the hippocampi is injured, memory and mood function can be weakened and turn into a major impairment. It also highlights that typically hippocampus injuries advance into cognitive dysfunction, epilepsy, and/or depression (Shetty, 2014). Hence, it is really important to look out and possibly get treatment if an individual has the same problem.

The human brain will always remain a subject of fascination for researchers and scientists, with its sophisticated workings that continue to present unanswered questions to them. In the context of this essay, the focus has been on understanding the implications of the impairment of the left hippocampus, as it is crucially responsible for memory, learning, and spatial navigation. As several theories have been discussed in relation to the damaged left

hippocampus, in which to shed light on the significance of memory formation and retrieval. Theories like standard consolidation theory (SCT), neuroplasticity theory, medial temporal lobes (MTL) theory, and multiple trace theory (MTT), critically showcased the relationship with what it would be like when the left hippocampal is damaged. The theories may have shown their support for the main focus of the essay, the damaged left hippocampal, but they also have their drawbacks and criticisms. Case studies, for instance, R.B.'s case put an emphasis on how impactful the hippocampal impairment, the left hippocampus specifically, is on memory function. Hence, it reinforces the critical role of the left hippocampi. In conclusion, the costs of having an impaired left hippocampus extend further beyond just memory deficits. As mentioned, it can have a negative influence on many cognitive activities. Therefore, due to the damaged left hippocampus, this essay showcased the biological and cognitive consequences from a broader perspective. When viewing and delving deeper into the damaged area of the brain structure, it can be understood these implications from theories and case studies provide valuable insights into the left hippocampal and highlight the importance of preserving hippocampal function.

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