

The damaged area highlighted in the provided image is known as the hippocampus, which is more specifically located in the left hemisphere of the brain. Scoville and Milner's (1957) discovery that the hippocampus is essential to human memory marked the beginning of the current period of study on hippocampal function (Howard & Eichenbaum, 2015). One of the brain's most researched neural systems is the hippocampus formation, which is located deep within the medial temporal lobes (MLT, Bird & Burgess, 2008). The temporal region of the cerebral cortex extends into the hippocampus (Gilbert & Brushfield, 2009, as cited in Dhikav & Anand, 2012). Externally, it can be recognized as an S-shaped layer of closely arranged neurons encircling the edge of the temporal lobe. It plays a significant part in memory and learning. Different stimuli can cause damage to this delicate and malleable structure (Dhikav & Anand, 2012). According to Frisoni et al. (2010), it is the first and most severely impacted structure in several neuropsychiatric conditions, including epilepsy and Alzheimer's disease (AD). This essay will critically discuss the biological and cognitive effects that may result from hippocampal damage and its pivotal theories, based on the provided image of the brain in the class module.

From a biological perspective, the hippocampus functions as a central location for memory consolidation and retrieval, having links to multiple cortical and subcortical areas. According to Scoville and Milner, severe amnesia is caused by injury to the hippocampus formation. According to their findings, those who suffer from significant injury to the medial temporal lobes seem unable to recall the events of their everyday lives as quickly as they occur. These patients' short-term memory appeared to be unharmed, but they quickly forgot things or became distracted easily (Deshmukh & Knierim, 2012). The seminal case of patient H.M., who underwent bilateral hippocampus removal for epilepsy treatment, is crucial to our understanding of the biological effects of hippocampal injury. After the procedure, the patient showed signs of profound

anterograde amnesia, or the inability to create new memories. In addition, he showed signs of partial retrograde amnesia, meaning that his recollections of early childhood were significantly clearer than those of events that happened three years before the surgery to remove his hippocampi was performed (Deshmukh & Knierim, 2012). In addition to all other research, the memory impairment in H.M. has motivated researchers to create animal models to understand the role of the brain in memory regulation (Jarrard, 1995). Although numerous researchers have cautioned that the damage in hippocampal ischemia is primarily associated with the medial temporal region, other researchers have utilized this clinical example to suggest that the hippocampal region is especially essential for long-term, explicit memory (Jarrard, 1995).

Beyond its biological implications, damage to the left hippocampus profoundly impacts cognitive functioning as well. A study concluded that hippocampus integrity is necessary for other cognitive processes. For instance, O'Keefe and colleagues found that the hippocampus is important for spatial navigation in rodents (O'Keefe and Dostrovsky, 1971; O'Keefe and Nadel, 1978; O'Keefe and Speakman, 1987, as cited in McCormick et al., 2018). This finding has since been thoroughly replicated in the human population (Maguire et al., 1998; Maguire et al., 2000; Maguire et al., 2006; Rosenbaum et al., 2000; Schinazi et al., 2013; Wolbers et al., 2007; Spiers and Maguire, 2006; Woollett and Maguire, 2011, as cited in McCormick et al., 2018). Furthermore, a sign of hippocampus damage is autobiographical memory impairment, which is defined by a person's inability to recollect specific prior events even though they are still aware of the events. The hippocampus plays a crucial role in the formation and retrieval of autobiographical memories, as evidenced by the impairment observed in both recent and distant memories (Nadel and Moscovitch, 1997; Winocur and Moscovitch, 2011; Kurczek et al., 2015, as cited in McCormick et al., 2018). According to neuroimaging studies (Addis et al., 2007a; Maguire et al., 2001, as cited

in McCormick et al., 2018), patients who retrieve autobiographical memories exhibit less stimulation in the hippocampus during this process, while compensatory activation occurs in other areas of the brain, such as the ventromedial prefrontal cortex. Patients suffering from hippocampal injury also have impaired future-thinking abilities, which is not surprising given the hippocampus's function in creating mental images for future events. According to the scene construction theory (Hassabis et al., 2007; Klein and Loftus, 2002; Squire et al., 2010; Dede et al., 2016, as cited in McCormick et al., 2018), the hippocampus creates spatially coherent scenes, which are crucial for the retrieval of memories and future imagination. Those with hippocampal impairment face significant difficulties when completing spatial navigation tasks. This is seen in situations when patients have difficulty creating mental scenes or providing precise descriptions of their neighborhoods, which are essential for navigation. Owing to its contribution to encoding spatial information and creating cognitive maps of surroundings, the hippocampus plays a crucial role in spatial cognition and navigation (McCormick et al., 2018).

Many theories on the role of the hippocampus have been proposed over the years, both biologically and cognitively. A theory that can be used to explain the biological implications of hippocampal injury is the standard model of consolidation (SMC), or standard consolidation theory. When H.M. underwent a bilateral medial temporal lobectomy in 1957 for epilepsy, Scoville and Milner discovered that he exhibited significant amnesia for declarative memories that were recent but not for previous recollections. Following hippocampal damage observed in patients and laboratory animals, the presence of progressively severe amnesia for recent recollections compared to remote memories was explained by the SMC (Dash et al., 2004). According to the notion (Winocor & Moscovitch, 2011), episodic and semantic memories are first formed in the hippocampus and then get consolidated in other parts of the brain in their original forms. The

involvement of the hippocampus is limited in time because it requires a certain structure to establish the connections required to generate a coherent memory and sustain it for a brief amount of time. As time goes on, memory can now be recalled without using the hippocampus because it has reorganized or consolidated in extra-hippocampal (neocortical) areas (Winocor & Moscovitch, 2011). As per the notion, a recent memory is vulnerable since it has not yet undergone consolidation, and a significant injury to the hippocampal region, which retains the memory representation, would destroy it. An interwoven extra-hippocampal network that encompasses the neocortex and other areas can represent memory, and damage to the hippocampus has little effect when consolidation is allowed enough time to finish (Winocor & Moscovitch, 2011). This type of memory is extremely resilient to disruption.

This theory has been questioned for almost ten years because of the conceptual and empirical problems that have been found. One of these problems is that the degree of retrograde amnesia (RA) varies according to the memory task and the induction technique (e.g., lesions and electroconvulsive shock). Furthermore, there is no suggested mechanism for the supposed transfer of memory from hippocampal to extrahippocampal areas, and there is a dearth of empirical evidence in favor of this theory. Moreover, Nadel et al. (2007) state that SMC is unable to account for the progressive transformation of episodic memories into more semantic forms. According to traditional SMC, memories eventually shift from depending on hippocampal connections to cortico-cortical connections. However, studies indicate that memories initially hold onto exact contextual information but eventually lose this knowledge and are less impacted by changes in context. This suggests that the process of consolidating and retrieving memories is more intricate than what SMC first suggested (Gisquet-Verrier & Riccio, 2022). Nadel and Moscovitch (1997) suggested the Multiple Trace Theory (MTT) as an alternate framework for this theory in response

to these drawbacks. In contrast to SMC, MTT predicts hippocampus engagement in the recall of remote memories, incorporating elements of cognitive map theory and component process models while also expanding upon them. Among the several predictions made by MTT, the most notable was that the hippocampus complex would be activated during the retrieval of distant memories. According to the core tenet of the Multiple Trace Theory (Nadel & Moscovitch, 1997), the hippocampus is always required for the recall of episodic memories in addition to being required for their registration. The SMC states that the hippocampus is thought to have a limited function in memory, mainly helping to consolidate declarative memories in preparation for their final storage in the neocortex. According to this prediction, unless neocortical conditions are at play, retrograde amnesia ought to be temporally graded, with recent memory being more impacted than remote memory (Squire, 1992; Dudai, 2004; Frankland & Bontempi, 2005). However, MTT argues that episodic memory retrieval requires MTL and, more specifically, the hippocampus. It implies that memories are encoded and bound by the hippocampus complex, resulting in many traces that get stronger with time. According to Moscovitch et al. (2005), MTT predicts that a lifetime of ungraded retrograde amnesia would be the outcome of significant hippocampus damage. Research on individuals with amnesia has produced data that both validates and refutes these beliefs. While some results support MTT and indicate ungraded impairment even with MTL injuries, others are consistent with the SMC, demonstrating temporally graded retrograde amnesia in patients with specific hippocampus injuries (Reed & Squire, 1998; Moscovitch et al., 2006; Warrington, 1996). Reassessing well-known amnesic patient H.M. demonstrated an ungraded impairment of autobiographical memory, confirming the role of the hippocampus in the recall of distant memories (Scoville & Milner, 1957; Steinworth, Levine & Corkin, 2005). This result, which

is in good agreement with MTT, supports the importance of hippocampal formation in the recovery of distant memories.

The scene construction theory (SCT) is another theory that can be closely related to the cognitive effects of hippocampal damage. According to the idea of scene construction, the hippocampus creates a scene to package information while a person is recalling prior events. After these scenes are created, information from a recalled event can be combined with other facts, and the same processes can be applied to create imaginative scenes that influence behavior by conjuring up new and unexpected possibilities (Sheldon & Levine, 2016). According to this theory of autobiographical memory, the creation and recollection of autobiographical memories depend on the construction of scenes. Neuropsychological cases of injury and neuroimaging studies provide evidence in favor of this approach (Rubin & Umanath, 2015). According to neuropsychological research (Greenberg et al., 2005; Mullally & Maguire, 2013), amnesia can result from injury to areas involved in scene formation, indicating the importance of scene construction in autobiographical memory. The role of the hippocampus and visual ventral stream in scene creation and autobiographical memory is further supported by neuroimaging research. When people recall autobiographical experiences, research utilizing methods like functional magnetic resonance imaging (fMRI) has repeatedly demonstrated activation in brain regions related to scene processing and memory retrieval (Baldassano et al., 2016; Cabeza et al., 2004). The phenomenological elements of autobiographical memory, like the feeling of relief, vividness, and conviction in memory accuracy, are also included in this approach. Research has indicated that memories devoid of spatial organization are interpreted more as semantic information than as autobiographical recollections, which results in less vividness, reliving, and confidence in their authenticity (Hassabis & Maguire, 2007; Eichenbaum et al., 1999). As a result, the addition of

scene construction strengthens these phenomenological elements, giving memories a more accurate, genuine, and vivid sense. Hassabis and Maguire (2009) proposed the SCT in response to the deficit in scene construction seen in individuals with bilateral hippocampal damage accounts of selective scene-processing deficits after hippocampal damage, and fMRI results that a normal hippocampus remains active when imagining past (Hassabis et. al., 2007) and future (Addis et al., 2007) scenes. According to the SCT, the hippocampus aids in the creation of atemporal scenes, which enable the event specifics of episodic memories and projected future experiences to be bound, martialized, and enacted within a logical spatial framework. Scene construction is therefore thought to support cognitive processes like spatial navigation, dreaming, and episodic memory in addition to envisioning the future. Most people use their imagination to recall events from the past and future planning.

The SCT offers an innovative paradigm for understanding the hippocampal function in cognition, with a focus on scene processing. The thorough integration of memory and perception processes within the hippocampus is one of SCT's main advantages. Graham, Barense, and Lee (2010) state that the hypothesis contends that the hippocampal formation and representation of complex situations are critical functions of the hippocampal region in addition to its involvement in memory. The hippocampus is constantly creating internal representations of scenes; in fact, it does so even when you are not expressly asked to do so, such as when you are remembering a past event, making travel plans, or envisioning the future (Mullally, Intraub, & Maguire, 2012). Furthermore, SCT shows an amazing ability to reconcile surprising results about hippocampus function. According to Lee et al. (2012), non-mnemonic perceptual deficiencies seen in tasks involving scene formation can be predicted and explained by SCT. SCT advances our knowledge of the diverse roles of the hippocampal region by offering a cohesive paradigm that takes into

account both the more recent perceptual deficiencies seen in hippocampal amnesia and more conventional mnemonic deficits. SCT's distinctive focus on scene processing as a fundamental hippocampal function is another asset. According to Lee et al. (2012), the hippocampus is especially good at describing scenes that we cannot see, which helps to create our subjective impression of a continuous and seamless world. This emphasis sets SCT apart from previous theories and emphasizes how crucial scene creation is to understanding hippocampal function. Despite its advantages, SCT may oversimplify the hippocampi's complicated role by eliminating memory as its main purpose. According to Ranganath (2010), SCT may not adequately account for the variety of roles ascribed to the hippocampal region, including mnemonic detail binding, because it places too much emphasis on scene processing. This oversimplification may reduce SCT's ability to fully explain the amount to which the hippocampus contributes to cognition. Although SCT emphasizes the significance of scene processing, it might not provide thorough support for other hippocampal processes.

In conclusion, this essay has explored the complex relationship that exists between hippocampus function, memory, and cognition, highlighting the critical role that it plays in creating our experiences. Numerous studies, ranging from groundbreaking research by Scoville and Milner to cutting-edge neuroimaging studies, highlight the importance of the hippocampal region in memory consolidation, spatial navigation, and autobiographical memory retrieval. Through the integration of theoretical viewpoints and empirical data, this essay advances our comprehension of the hippocampal as a dynamic center that coordinates cognitive functions essential to human experience. However, future directions in research might additionally improve our understanding and provide significant implications. Studying memory consolidation theories other than the conventional MTT and SMC offers an interesting direction for future research. Upon

reactivation, it is possible, for example, that additional nodes or retrieval routes are continuously added to the initial memory trace instead of multiple traces. Researchers can further our understanding of long-term consolidation processes and promote an in-depth study of physiologically and psychologically feasible mechanisms underlying memory formation and retrieval by exploring these alternate theories (Nadel & Moscovitch, 1997). Moreover, due to their profound amnesia, patients with hippocampus impairment probably continue to possess a lot of undiscovered cognitive domains (McCormick et al., 2018). But these patients have a rare chance to learn how the brain's other regions respond to hippocampus damage. Since injury to patients usually occurs along its whole length, it is invaluable for examining the distinct functional contributions of the anterior and posterior hippocampal regions. Furthermore, barely any knowledge exists about the temporal dynamics of scene construction or autobiographical memory retrieval (Fuentemilla et al., 2014; Kaplan et al., 2017, as referenced in McCormick et al., 2018). Although SCT offers insightful information about the function of scene processing in the hippocampus, more research and development may be necessary to make SCT applicable to non-scene-related tasks (Ranganath, 2010).

References

- Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia*, 45(7), 1363–1377. <https://doi.org/10.1016/j.neuropsychologia.2006.10.016>
- Baldassano, C., Esteva, A., Fei-Fei, L., & Beck, D. M. (2016). Two distinct scene-processing networks connecting vision and memory. *Eneuro*, 3(5). <https://doi.org/10.1523/eneuro.0178-16.2016>
- Bird, C. M., & Burgess, N. (2008). The hippocampus and memory: Insights from spatial processing. *Nature Reviews Neuroscience*, 9(3), 182–194. <https://doi.org/10.1038/nrn2335>
- Cabeza, R., Prince, S. E., Daselaar, S. M., Greenberg, D. L., Budde, M., Dolcos, F., LaBar, K. S., & Rubin, D. C. (2004). Brain activity during episodic retrieval of autobiographical and laboratory events: An fmri study using a novel photo paradigm. *Journal of Cognitive Neuroscience*, 16(9), 1583–1594. <https://doi.org/10.1162/0898929042568578>
- Dash, P. K., Hebert, A. E., & Runyan, J. D. (2004). A unified theory for systems and cellular memory consolidation. *Brain Research Reviews*, 45(1), 30–37. <https://doi.org/10.1016/j.brainresrev.2004.02.001>
- Deshmukh, S. S., & Knierim, J. J. (2012). Hippocampus. *WIREs Cognitive Science*, 3(2), 231–251. <https://doi.org/10.1002/wcs.1164>
- Dhikav, V., & Anand, K. (2012). Hippocampus in health and disease: An overview. *Annals of Indian Academy of Neurology*, 15(4), 239. <https://doi.org/10.4103/0972-2327.104323>
- Dudai, Y. (2004). The neurobiology of consolidations, or, how stable is the Engram? *Annual Review of Psychology*, 55(1), 51–86. <https://doi.org/10.1146/annurev.psych.55.090902.142050>
- Eichenbaum, H., Dudchenko, P., Wood, E., Shapiro, M., & Tanila, H. (1999). The hippocampus, memory, and place cells. *Neuron*, 23(2), 209–226. [https://doi.org/10.1016/s0896-6273\(00\)80773-4](https://doi.org/10.1016/s0896-6273(00)80773-4)
- Frankland, P. W., & Bontempi, B. (2005). The organization of recent and Remote Memories. *Nature Reviews Neuroscience*, 6(2), 119–130. <https://doi.org/10.1038/nrn1607>
- Frisoni, G. B., Fox, N. C., Jack, C. R., Scheltens, P., & Thompson, P. M. (2010). The clinical use of structural MRI in alzheimer disease. *Nature Reviews Neurology*, 6(2), 67–77. <https://doi.org/10.1038/nrneurol.2009.215>

- Gisquet-Verrier, P., & Riccio, D. C. (2022). Revisiting systems consolidation and the concept of consolidation. *Neuroscience & Biobehavioral Reviews*, 132, 420–432.
<https://doi.org/10.1016/j.neubiorev.2021.12.003>
- Graham, K. S., Barense, M. D., & Lee, A. C. H. (2010). Going beyond LTM in the MTL: A synthesis of neuropsychological and neuroimaging findings on the role of the medial temporal lobe in memory and perception. *Neuropsychologia*, 48(4), 831–853.
<https://doi.org/10.1016/j.neuropsychologia.2010.01.001>
- Greenberg, D., Eacott, M., Brechin, D., & Rubin, D. (2005). Visual memory loss and autobiographical amnesia: A case study. *Neuropsychologia*, 43(10), 1493–1502.
<https://doi.org/10.1016/j.neuropsychologia.2004.12.009>
- Hassabis, D., & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, 11(7), 299–306. <https://doi.org/10.1016/j.tics.2007.05.001>
- Hassabis, D., & Maguire, E. A. (2009). The construction system of the brain. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1521), 1263–1271.
<https://doi.org/10.1098/rstb.2008.0296>
- Hassabis, D., Kumaran, D., Vann, S. D., & Maguire, E. A. (2007). Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences*, 104(5), 1726–1731. <https://doi.org/10.1073/pnas.0610561104>
- Jarrard, L. E. (1995). What does the hippocampus really do? *Behavioural Brain Research*, 71(1–2), 1–10. [https://doi.org/10.1016/0166-4328\(95\)00034-8](https://doi.org/10.1016/0166-4328(95)00034-8)
- Lee, A. C., Yeung, L.-K., & Barense, M. D. (2012). The hippocampus and visual perception. *Frontiers in Human Neuroscience*, 6. <https://doi.org/10.3389/fnhum.2012.00091>
- McCormick, C., Ciaramelli, E., De Luca, F., & Maguire, E. A. (2018). Comparing and contrasting the cognitive effects of hippocampal and ventromedial prefrontal cortex damage: A review of human lesion studies. *Neuroscience*, 374, 295–318.
<https://doi.org/10.1016/j.neuroscience.2017.07.066>
- Moscovitch, M., Nadel, L., Winocur, G., Gilboa, A., & Rosenbaum, R. S. (2006). The Cognitive Neuroscience of remote episodic, semantic and Spatial Memory. *Current Opinion in Neurobiology*, 16(2), 179–190. <https://doi.org/10.1016/j.conb.2006.03.013>
- Moscovitch, M., Rosenbaum, R. S., Gilboa, A., Addis, D. R., Westmacott, R., Grady, C., McAndrews, M. P., Levine, B., Black, S., Winocur, G., & Nadel, L. (2005). Functional neuroanatomy of remote episodic, Semantic and Spatial Memory: A unified account based on multiple trace theory. *Journal of Anatomy*, 207(1), 35–66.
<https://doi.org/10.1111/j.1469-7580.2005.00421.x>

- Mullally, S. L., & Maguire, E. A. (2013). Exploring the role of space-defining objects in constructing and maintaining imagined scenes. *Brain and Cognition*, 82(1), 100–107. <https://doi.org/10.1016/j.bandc.2013.02.013>
- Mullally, S. L., Intraub, H., & Maguire, E. A. (2012). Attenuated boundary extension produces a paradoxical memory advantage in amnesic patients. *Current Biology*, 22(4), 261–268. <https://doi.org/10.1016/j.cub.2012.01.001>
- Nadel, L., & Moscovitch, M. (1997). Memory consolidation, retrograde amnesia and the hippocampal complex. *Current Opinion in Neurobiology*, 7(2), 217–227. [https://doi.org/10.1016/s0959-4388\(97\)80010-4](https://doi.org/10.1016/s0959-4388(97)80010-4)
- Nadel, L., Winocur, G., Ryan, L., & Moscovitch, M. (2007). Systems consolidation and Hippocampus: Two Views. *Debates in Neuroscience*, 1(2–4), 55–66. <https://doi.org/10.1007/s11559-007-9003-9>
- Ranganath, C. (2010). A unified framework for the functional organization of the medial temporal lobes and the phenomenology of episodic memory. *Hippocampus*, 20(11), 1263–1290. <https://doi.org/10.1002/hipo.20852>
- Reed, J. M., & Squire, L. R. (1998). Retrograde amnesia for facts and events: Findings from four new cases. *The Journal of Neuroscience*, 18(10), 3943–3954. <https://doi.org/10.1523/jneurosci.18-10-03943.1998>
- Rubin, D. C., & Umanath, S. (2015). Event memory: A theory of memory for laboratory, autobiographical, and fictional events. *Psychological Review*, 122(1), 1–23. <https://doi.org/10.1037/a0037907>
- Scoville, W. B., & Milner, B. (1957). Loss of recent memory after bilateral hippocampal lesions. *Journal of Neurology, Neurosurgery & Psychiatry*, 20(1), 11–21. <https://doi.org/10.1136/jnnp.20.1.11>
- Sheldon, S., & Levine, B. (2016). The role of the hippocampus in memory and mental construction. *Annals of the New York Academy of Sciences*, 1369(1), 76–92. <https://doi.org/10.1111/nyas.13006>
- Squire, L. R. (1992). Memory and the hippocampus: A synthesis from findings with rats, monkeys, and humans. *Psychological Review*, 99(2), 195–231. <https://doi.org/10.1037/0033-295x.99.2.195>
- Steinvorth, S., Levine, B., & Corkin, S. (2005). Medial temporal lobe structures are needed to re-experience remote autobiographical memories: Evidence from H.M. and W.R. *Neuropsychologia*, 43(4), 479–496. <https://doi.org/10.1016/j.neuropsychologia.2005.01.001>

Warrington, E. K. (1996). Studies of retrograde memory: A long-term view. *Proceedings of the National Academy of Sciences*, 93(24), 13523–13526.
<https://doi.org/10.1073/pnas.93.24.13523>

Winocur, G., & Moscovitch, M. (2011). Memory transformation and systems consolidation. *Journal of the International Neuropsychological Society*, 17(05), 766–780.
<https://doi.org/10.1017/s1355617711000683>